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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
Coastal Zone & Estuarine Studies Division
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

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MEMORANDUM FOR: F/NW - William Stelle
F/SW - Hilda Diaz-Soltero

THRU: F/NWC - Usha Varanasi Usha Varanasi

FROM: F/NWC1 - Michael H. Schiewe Michael H. Schiewe

SUBJECT: Conclusions Regarding the Updated Status of West Coast Coho Salmon

The West Coast Salmon Biological Review Team has updated its assessment of the status of coho salmon from Washington, Oregon, and California, originally completed in 1994. The attached report summarizes the conclusions from this updated review.

As previously agreed, a copy of this memorandum, with the conclusions for the three southern-most ESUs omitted, has been distributed to the state, tribal, and federal co-managers of the candidate species ESUs. We have asked that the comanagers provide comments by 31 January 1997, after which time we will finalize the candidate species sections of the report.

Please feel free to contact either Robin Waples or myself if you have any questions regarding this report.

cc: F/SWC - Tillman
F/NWO2 - Robinson
F/NWO3 - Wyland, Griffin, Jones
F/SWO - Lecky, Wingert
GCNW - Bancroft
BRT members

DRAFT

Status Review Update for Coho Salmon from Washington, Oregon, and California

Prepared by the
West Coast Coho Salmon Biological Review Team*

20 December 1996

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*The Biological Review Team (BRT) for West Coast coho salmon included Peggy Busby, Bob Emmett, Dr. Jeffrey Hard, Dr. Orlay Johnson, Dr. Robert Iwamoto, Dr. Robert Kope, Dr. Conrad Mahnken, Gene Matthews, Dr. Michael Schiewe, David Teel, Dr. Thomas Wainwright, William Waknitz, Dr. Robin Waples, Laurie Weitkamp, Dr. John Williams, and Dr. Gary Winans, all from the Northwest Fisheries Science Center (NWFSC), Dr. Pete Adams from the Southwest Fisheries Science Center (SWFSC) and Gregory Bryant from the NMFS Southwest Region.

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BACKGROUND

In 1993 the National Marine Fisheries Service (NMFS) received several petitions to list coho salmon under the U.S. Endangered Species Act (ESA), and the NMFS announced its intention to conduct a coast-wide status review shortly thereafter. A biological status review was initiated by the NMFS's Biological Review Team (BRT), culminating in the publication of a status review for West Coast (Washington, Oregon, and California) coho salmon (Weitkamp et al. 1995). In July 1995, on the basis of this status review and other information regarding conservation measures and factors for decline, the NMFS identified six evolutionarily significant units (ESUs) for coho salmon, and proposed listing the three southern-most ESUs as threatened, identified two ESUs as candidates for possible future listing, and determined that listing was not warranted for one ESU (60 FR 38011, July 25, 1995). In October 1996, the NMFS announced a final listing of the southern-most ESU (Central California coast) as a threatened species, and postponed decisions on the two other proposed ESUs and two candidate-species ESUs for 6 months to resolve outstanding scientific disagreements (61 FR 56138, October 31, 1996).

Since July 1995, NMFS scientific staff have been meeting with federal, state, and tribal agency ("comanager") biologists with knowledge of coho salmon biology and status in an effort to resolve uncertainties associated with the candidate ESUs (lower Columbia River/southwest Washington and Puget Sound/Strait of Georgia), and to update information and resolve disagreements regarding the ESUs proposed for listing (Central California coast, Southern Oregon/Northern California coasts, and Oregon coast). These meetings have resulted in a variety of documents and other information provided to NMFS since the completion of the original status review.

This report supplements the original status review report (Weitkamp et al. 1995), providing updated information and analysis received since the time that review was conducted. In the first section of this document, the BRT reviews previous conclusions, comanager and peer-review comments and other information received. In the second section, new information relating to ESU boundaries and extinction risk is discussed. The final section summarizes the BRT conclusions regarding these issues.

Key Questions in ESA Evaluations

In determining whether a listing under the ESA is warranted, two key questions must be addressed :

1) Is the entity in question a "species" as defined by the ESA?
2) If so, is the "species" threatened or endangered?

These two questions are addressed separately in this report. If it is determined that a listing(s) is warranted, then NMFS is required by law (1973 ESA Sec. 4(a)(1)) to identify one or more of the following factors responsible for the species' threatened or endangered status: 1) destruction or modification of habitat; 2) overutilization by humans; 3) disease or predation; 4) inadequacy of existing regulatory mechanisms; or 5) other natural or human factors. This status review does not formally address factors for decline, except insofar as they provide information about the degree of risk faced by the species in the future. Factors for decline are addressed in a separate document at the time of listing (61 FR 56138, October 31, 1996).

The "Species" Question

As amended in 1978, the ESA allows listing of "distinct population segments" of vertebrates as well as named species and subspecies. However, the ESA provides no specific guidance for determining what constitutes a distinct population, and the resulting ambiguity has led to the use of a variety of approaches for considering vertebrate populations. To clarify the issue for Pacific salmon, NMFS published a policy describing how the agency will apply the definition of "species" in the ESA to anadromous salmonid species, including sea-run cutthroat trout and steelhead (NMFS 1991). A more detailed discussion of this topic appeared in the NMFS "Definition of Species" paper (Waples 1991). The NMFS policy stipulates that a salmon population (or group of populations) will be considered "distinct" for purposes of the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. An ESU is defined as a population that 1) is substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species.

The term "evolutionary legacy" is used in the sense of "inheritance"--that is, something received from the past and carried forward into the future. Specifically, the evolutionary legacy of a species is the genetic variability that is a product of past evolutionary events and that represents the reservoir upon which future evolutionary potential depends. Conservation of these genetic resources should help to ensure that the dynamic process of evolution will not be unduly constrained in the future.

The NMFS policy identifies a number of types of evidence that should be considered in the species determination. For each of the two criteria (reproductive isolation and evolutionary legacy), the NMFS policy advocates a holistic approach that considers all types of available information as well as their strengths and limitations. Isolation does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in different population units. Important types of information to consider include natural rates of straying and recolonization, evaluations of the efficacy of natural barriers, and measurements of genetic differences between populations. Data from protein electrophoresis or DNA analyses can be particularly useful for this criterion because they reflect levels of gene flow that have occurred over evolutionary time scales.

The key question with respect to the second criterion is, If the population became extinct, would this represent a significant loss to the ecological/genetic diversity of the species? Again, a variety of types of information should be considered. Phenotypic and life history traits such as size, fecundity, migration patterns, and age and time of spawning may reflect local adaptations of evolutionary importance, but interpretation of these traits is complicated by their sensitivity to environmental conditions. Data from protein electrophoresis or DNA analyses provide valuable insight into the process of genetic differentiation among populations but little direct information regarding the extent of adaptive genetic differences. Habitat differences suggest the possibility for local adaptations but do not prove that such adaptations exist.

The "Extinction Risk" Question

The ESA (section 3) defines the term "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." The term "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." NMFS considers a variety of information in evaluating the level of risk faced by an ESU. Important considerations include 1) absolute numbers of fish and their spatial and temporal distribution; 2) current abundance in relation to historical abundance and carrying capacity of the habitat; 3) trends in abundance, based on indices such as dam or redd counts or on estimates of recruit-to-spawner ratios; 4) natural and human-influenced factors that cause variability in survival and abundance; 5) possible threats to genetic integrity (e.g., selective fisheries and interactions between hatchery and natural fish); and 6) recent events (e.g., a drought or a change in management) that have predictable short-term consequences for abundance of the ESU. Additional risk factors, such as disease prevalence or changes in life history traits, may also be considered in evaluating risk to populations.

According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific information available regarding its current status, after taking into consideration conservation measures that are proposed or are in place. In this review, the BRT does not evaluate likely or possible effects of conservation measures. Therefore, the BRT does not make recommendations as to whether identified ESUs should be listed as threatened or endangered species, because that determination requires evaluation of factors not considered. Rather, the BRT drew scientific conclusions about the risk of extinction faced by identified ESUs under the assumption that present conditions will continue (recognizing, of course, that natural demographic and environmental variability is an inherent feature of "present conditions"). Conservation measures will be taken into account by the NMFS Northwest and Southwest Regional Offices in making listing recommendations.

Artificial Propagation

NMFS policy (Hard et al. 1992, NMFS 1993) stipulates that in determining 1) whether a population is distinct for purposes of the ESA, and 2) whether an ESA species is threatened or endangered, attention should focus on "natural" fish, which are defined as the progeny of naturally spawning fish (Waples 1991). This approach directs attention to fish that spend their entire life cycle in natural habitat and is consistent with the mandate of the ESA to conserve threatened and endangered species in their native ecosystems. Implicit in this approach is the recognition that fish hatcheries are not a substitute for natural ecosystems.

Nevertheless, artificial propagation is important to consider in ESA evaluations of anadromous Pacific salmonids for several reasons. First, although natural fish are the focus of ESU determinations, possible effects of artificial propagation on natural populations must also be evaluated. For example, stock transfers might change the genetic or life history characteristics of a natural population in such a way that the population might seem either less or more distinctive than it was historically. Artificial propagation can also alter life history characteristics such as smolt age and migration and spawn timing. Second, artificial propagation poses a number of risks to natural populations that may affect their risk of extinction or endangerment. In contrast to most other types of risk for salmon populations, those arising from artificial propagation are often not reflected in traditional indices of population abundance. For example, to the extent that habitat degradation, overharvest, or hydropower development have contributed to a population's decline, these factors will already be reflected in population abundance data and accounted for in the risk analysis. The same is not true of artificial propagation. Hatchery production may mask declines in natural populations that will be missed if only raw population abundance data are considered. Therefore, a true assessment of the viability of natural populations cannot be attained without information about the contribution of naturally spawning hatchery fish. Furthermore, even if such data are available, they will not in themselves provide direct information about possibly deleterious effects of fish culture. Such an evaluation requires consideration of the genetic and demographic risks of artificial propagation for natural populations. The sections on artificial propagation in this report are intended to address these concerns.

Finally, if any natural populations are listed under the ESA, then it will be necessary to determine the ESA status of all associated hatchery populations. Evaluations of the ESA status of hatchery populations in ESUs that were proposed for listing are currently underway.

SUMMARY OF PREVIOUS CONCLUSIONS

The BRT last considered the status of coho salmon in summer 1994, and transmitted its conclusions to the regions on September 2, 1994. A full status review was published in

September 1995 (Weitkamp et al. 1995). Below is a summary of the conclusions that the BRT reached in that review.

The Species Question

As described in the status review (Weitkamp et al.1995), the BRT considered evidence from numerous sources to identify ESU boundaries. In general, evidence from physical environment and ocean conditions/upwelling patterns, estuarine and freshwater fish and terrestrial vegetation distributions, and coho salmon river entry and spawn timing and marine coded-wire-tag recovery patterns proved to be most informative. Genetic data was used to indicate relative levels of reproductive isolation between populations and groups of populations. Based on this information, the BRT identified six ESUs for west coast coho salmon populations: 1) Central California coast, 2) Southern Oregon/Northern California coasts, 3) Oregon coast, 4) Lower Columbia River/southwest Washington coast, 5) Olympic Peninsula, and 6) Puget Sound/Strait of Georgia.

The only comments the BRT received on proposed ESU boundaries were for the Lower Columbia River/southwest Washington coast ESU and its boundary with the Olympic Peninsula ESU (see Comanager and Peer Review Comments Section). Furthermore, no substantial new information was received that related to boundaries for other ESUs. Accordingly, only the boundaries of the Lower Columbia River/southwest Washington coast ESU will be considered further. The following briefly describes the BRT conclusions regarding the boundaries of the Lower Columbia River/southwest Washington coast ESU.

When considering coho salmon populations from southwest Washington and the lower Columbia River, the BRT, after considerable discussion and debate, decided to group coho salmon populations from these two areas into a single ESU. This grouping was based on evidence indicating physical and biogeographical similarities and similarities in the characteristics of coho salmon inhabiting those areas, both of which were distinct from adjacent areas to the north and south. In particular, both areas shared similar hydrology, topography, and climate; the Columbia River, Willapa Bay and Grays Harbor have extremely large estuaries with extensive mud and sand flats and similar estuarine fish faunas. Coho salmon from southwest Washington and the lower Columbia River were also genetically most similar to each other, based on genetic information available at the time (which consisted of samples from a total 22 hatchery and wild populations in the Columbia River and 5 hatchery populations from southwest Washington). In reaching this conclusion, the BRT recognized that southwest Washington, especially northern tributaries to the Chehalis River, had many environmental, climatic, and biological similarities to Olympic Peninsula basins, and the coded-wire tag recoveries patterns from southwest Washington populations were much more similar to patterns from other Washington coastal populations than they were to patterns from lower Columbia River populations. The BRT further recognized that southwest Washington had unique features--it formed the transition zone between the moderately wet Oregon coast and the extremely wet Olympic Peninsula, and its rivers, although similar in many respects to lower Columbia River tributaries, drained directly into the Pacific Ocean. However, despite similarities to other areas and unique characteristics, the BRT concluded that the majority of the evidence supported a single lower Columbia River/southwest Washington coast ESU.

Once the BRT concluded that coho salmon from the southwest Washington coast and the lower Columbia River formed a single ESU, the location of its border with the Olympic Peninsula had to be identified. This also prompted debate within the BRT because of the broad transition zone between southwest Washington and the Olympic Peninsula. In particular, tributaries draining the northern part of the Chehalis River Basin are typical of Olympic Peninsula basins with respect to hydrology, topography, and climate, while in most other respects the Chehalis River Basin is physically and biologically similar to other southwest Washington coast basins. In addition, river basins between the Chehalis and Quinault Rivers (Humptulips, Copalis, and Moclips Rivers) drain low-elevation coastal areas and have flow characteristics typical of rivers farther south. Although some Chehalis River tributaries share traits with Olympic Peninsula rivers, BRT members ultimately decided that the region between Point Grenville and Grays Harbor was most similar to southwest Washington, so the northern boundary of the lower Columbia River/southwest Washington coast ESU was placed at Point Grenville, between the Copalis and Quinault Rivers.

Assessment of Extinction Risk

Based on the best information available at the time of the status review, which often consisted of data only through 1993, the BRT identified a geographic trend in the status of coho salmon stocks south of the Canadian border, with the southernmost and eastern-most stocks in the worst condition. Throughout the regions reviewed, there had been recent declines in coho salmon abundance, and 1994 runs were predicted to be the worst on record in many river basins.

1) Central California coast

All coho salmon stocks south of Punta Gorda were depressed relative to past abundance, but there were limited data to assess population numbers or trends. The main stocks in this region had been heavily influenced by hatcheries, and there were apparently few native coho salmon left in this region. The apparent low escapements in these rivers and streams, in conjunction with heavy historical hatchery production, suggested that the natural populations were not self-sustaining. The status of coho salmon stocks in most small coastal tributaries was not well known, but these populations were small. There was unanimous agreement among the BRT that natural populations of coho salmon in this ESU were in danger of extinction.

This conclusion was tempered by major uncertainties regarding actual abundance of coho salmon in the region and the genetic integrity of stocks that had been influenced by hatchery fish.

2) Southern Oregon/northern California coasts

All coho salmon stocks between Punta Gorda and Cape Blanco were depressed relative to past abundance, but there were limited data to assess population numbers or trends. The main stocks in this region (Rogue River, Klamath River, and Trinity River) were heavily influenced by hatcheries, apparently with little natural production in mainstem rivers. The apparent declines in production in these rivers, in conjunction with heavy hatchery production, suggested that the natural populations were not self-sustaining. The status of coho salmon stocks in most small coastal tributaries was not well known, but these populations were small. There was unanimous agreement among the BRT that coho salmon in this ESU were not in danger of extinction, but were likely to become endangered in the foreseeable future if present trends continued.

There was substantial uncertainty regarding abundance of coho salmon and the influence of hatchery production on natural populations.

3) Oregon coast

There were extensive survey data available for coho salmon in this region. Overall, spawning escapements had declined substantially during this century, and may have been at less than 5% of their abundance in the early 1900s. Average spawner abundance had been relatively constant since the late 1970s, but pre-harvest abundance had declined. Average recruits-per-spawner may also have declined. Coho salmon populations in most major rivers appeared to have had heavy hatchery influence, but some tributaries may have been sustaining native stocks. The BRT concluded that coho salmon in this ESU were not at immediate risk of extinction but were likely to become endangered in the future if present trends continued.

For this ESU, information on trends and abundance were better than for the more southerly ESUs. Main uncertainties in the assessment included the extent of straying of hatchery fish, the influence of such straying on natural population trends and sustainability, the condition of freshwater habitat, and the influence of ocean conditions on population sustainability.

4) Lower Columbia River/southwest Washington coast

The BRT concluded that they could not at that time identify any remaining natural populations of coho salmon in the lower Columbia River (excluding the Clackamas River) or along the Washington coast south of Point Grenville that warranted protection under the ESA, although this conclusion for the southwest Washington portion was provisional because of the lack of definite information at that time. The Clackamas River produced moderate numbers of natural coho salmon. The Clackamas River late-run coho salmon population was relatively stable, but depressed and vulnerable to overharvest. Its small geographic range and low abundance made it particularly vulnerable to environmental fluctuations and catastrophes, so this population may have been at risk of extinction despite relatively stable spawning escapements in the recent past. As noted above, the BRT could not reach a definite conclusion regarding the relationship of Clackamas River late-run coho salmon to the historic lower Columbia River ESU. However, the BRT did conclude that *if* the Clackamas River late-run coho salmon was a native run that represented a remnant of a lower Columbia River ESU, the ESU was not presently in danger of extinction, but was likely to become so in the foreseeable future if present conditions continued.

The main uncertainties in this assessment were the extent to which native, naturally reproducing fish were still present in the Clackamas, Sandy, and Chehalis River Basins, the sustainability of natural production in these systems, and the influence of hatchery fish on genetic integrity of natural populations. In other areas in southwest Washington, not enough information was available to indicate whether native, naturally reproducing populations remained.

5) Olympic Peninsula

Coho salmon abundance within this ESU was moderate, but stable. These stocks had been reduced from historical levels by large-scale habitat degradation in the lower river basins, but there was a significant portion of coho salmon habitat in several rivers protected within the boundaries of Olympic National Park. This habitat refuge, along with the relatively moderate use of hatchery production (primarily with native stocks), appeared to have protected these coho salmon stocks from the serious losses experienced by adjacent regions. While there was continuing cause for concern about habitat destruction and hatchery practices within this ESU, the BRT concluded that there was sufficient native, natural, self-sustaining production of coho salmon that this ESU was not in danger of extinction, and was not likely to become endangered in the foreseeable future unless conditions changed substantially.

6) Puget Sound/Strait of Georgia

Coho salmon within this ESU were abundant, and, with some exceptions, run sizes and natural spawning escapements had been generally stable. However, the magnitude of artificial propagation of coho salmon in this ESU was extremely large, and, although its impacts on native, natural coho salmon populations were largely unknown, the extensive artificial propagation made it difficult to identify natural populations that were clearly self sustaining. In addition, continuing loss of habitat, extremely high harvest rates, and a sharp recent decline in average size of spawners indicated that there were substantial risks to whatever native production remained. There was concern that if present trends continued, this

ESU was likely to become endangered in the foreseeable future. However, the size data examined were heavily influenced by fishery data from the Puget Sound. These fisheries targeted primarily hatchery stocks, and it was not known at that time to what extent the trends in size were influenced by hatchery fish. The extent of hatchery contribution to the natural spawning escapement and to natural production was unclear, as were the potential effects this contribution may have had on the population genetics and ecology of this ESU. Further consideration of this ESU was thought to be warranted to attempt to clarify some of these uncertainties.

Four areas of concern and uncertainty for this ESU were identified for further review: the sustainability of apparent high harvest rates on natural populations, trends in adult body size, demographic and genetic effects of hatchery fish on natural production, and information on habitat conditions.

COMANAGER AND PEER REVIEW COMMENTS

Comments on the status review were received from California Department of Fish and Game (CDFG) (1995),Oregon Department of Fish and Wildlife (ODFW) (1994, 1995b), and Washington Department of Fish and Wildlife (WDFW) (1995), as well as peer review comments from Jennifer Nielsen (1995) and Tom Nickelson (1995). Nielsen's comments related primarily to interpretation of genetic data in California. CDFG concurred with NMFS' designation of ESU boundaries in California and with the proposed listing of the Central California coast and the Northern California / Southern Oregon coasts ESUs as threatened.

Nickelson's most substantive comments pertained to the analysis of abundance data for the Oregon coast and the Olympic Peninsula. His comments were also voiced by ODFW (1994). The thrust of their argument was that the decline on the Oregon coast was overstated in the Status Review because terminal runs were expanded using Oregon Production Index (OPI) harvest rates, while more precise and representative harvest rates can be calculated from coded-wire-tag (CWT) data. If these are used, the decline in Oregon coast natural (OCN) coho salmon is not as sharp. Secondly, they argued that the BRT used primarily escapement data on the Oregon coast and terminal run size for the Olympic Peninsula, and that this is an unfair comparison. If the BRT examined similar data, they argued, similar trends for the Oregon coast and the Olympic Peninsula would be seen. Both (Nickelson 1994, ODFW 1994, 1995b) also argued that the BRT had overstated the impact of hatchery fish on natural spawning population on the Oregon Coast. ODFW (1994) further argued that population levels at <5% of historic levels should not be a concern because the habitat is only capable of supporting 10% of historic abundance, so recent spawning escapements are at, or near, maximum sustainable yield levels. ODFW(1994) also suggested that the risk to the Columbia River/Southwest Washington ESU was overstated because the Clackamas River population, though depressed, was stable, and there were large numbers (130,000 [as reported by Hiss and Knudsen 1993]) of natural spawners in Grays Harbor. ODFW (1995b) further argued that spawning escapement in coastal streams had been stable since 1977, and that NMFS had failed to adequately consider conservation measures.

Northwest Indian Fish Commission (NWIFC) and WDFW (1996) commented on Nickelson's critique of the coho salmon status review, and particularly disagreed with his statement that ".. the data suggests more similarities that differences in status .." between the Oregon coast and Olympic Peninsula ESUs. NWIFC and WDFW provided several lines of evidence indicating differences between the two ESUs. Based on these differences and additional information on the status and management of the Olympic Peninsula ESU, they concluded that the BRT's assessment of the ESU as "not warranted" was appropriate.

Bob Hayman (1995) also rebutted the BRT's assessment of risks for Puget Sound populations. He argued that the decline in the size of fish landed in fisheries was attributable to an increase in the proportion of hatchery fish in the harvest. He also argued that degree of hatchery influence was overstated in the status review because the BRT only examined the proportion of hatchery fish in the terminal runs, rather than the opportunity for hatchery fish to breed with natural spawners. Also, the spatial distribution is such that most of the habitat in Puget Sound is managed for natural escapement, and he argued that the BRT should have paid more attention to the spatial distribution of hatchery influence.

WDFW's (1995) principle comments pertained to the process used by the BRT in reviewing the status of Washington ESUs. They felt that the BRT should have consulted more with state and tribal biologists in interpreting stock status information.

The only comments we received concerning ESU boundaries consisted of verbal comments from fisheries staff with the Quinault Indian Nation and written comments from WDFW and NWIFC (1996), both regarding ESU boundaries in southwestern Washington. Quinault Indian Nation staff felt that the boundary between the Olympic Peninsula and Lower Columbia River/southwest Washington coast ESUs should be moved from its location at Point Grenville (between the Copalis and Quinault Rivers) to some point further south so that the Chehalis River was included in the Olympic Peninsula ESU. They argued that the Chehalis River, particularly its northern tributaries, was more similar with respect to environment and flow characteristics to Olympic Peninsula rivers than to tributaries to Willapa Bay and the lower Columbia River, and therefore the Chehalis River should be part of the Olympic Peninsula ESU. Quinault staff also expressed concerns that the genetic samples used in the status review did not represent the genetic characteristics of naturally spawning fish in southwest Washington.

WDFW and NWIFC (1996) did not comment on the boundary between the Olympic Peninsula and Lower Columbia River/southwest Washington coast ESUs, but instead argued that the latter ESU should be split into two separate ESUs--a southwest Washington coast ESU and a lower Columbia River ESU. Their primary reasoning for the separation came from NMFS' new genetic data (NMFS, unpublished) and marine coded-wire tag recovery patterns presented in the status review (Weitkamp et al. 1995). They argued that the new genetic data, which included samples from populations in southwest Washington that had not been sampled previously, indicated separation between southwest Washington and the lower Columbia River populations that was comparable in magnitude to separation between other groups of populations that were considered separate ESUs. With respect to the coded-wire tag recovery patterns, they pointed to the large difference in patterns between southwest Washington and lower Columbia River populations, and the similarity in recovery patterns between southwest Washington and other coastal Washington populations. Finally, WDFW and NWIFC (1996) argued that various faunas in southwest and coastal Washington are distinct from lower Columbia River faunas. Taken together, they felt that these various lines of evidence strongly supported separating the Lower Columbia River/southwest Washington coast ESU into two ESUs.

OTHER INFORMATION RECEIVED

Since completing the status review for coastwide coho salmon (Weitkamp et al. 1995), the NMFS has received new and updated information on coho salmon in British Columbia, Washington, Oregon, and California that is critical to assessing the current status coho salmon ESUs. This new information generally consists of updates of existing data series, new data series, new analyses of various factors, and new information about management practices. This information is listed by ESU in Table 1.

As part of this new information, NMFS received several reports in fall 1996 that provided substantial new information about risks faced by many coho salmon ESUs. These documents included reports by NWIFC and WDFW on aspects of the status of coho salmon in Puget Sound, southwest Washington, and the Olympic Peninsula (NWIFC and WDFW 1996, WDFW and NWIFC 1996), and the results of a 1995 study on straying by hatchery fish in Hood Canal and southwest Washington (Ruggerone 1996). NMFS also received numerous draft Oregon Coastal Salmon Restoration Initiative (OCSRI) Science Team products (OCSRI 1996a), including the results of three approaches to population viability analysis (Nickelson and Lawson 1996, Chilcote 1996).

Among the draft recommendations from the OCSRI Science Team are a set of proposed "listing criteria" (OCSRI Science Team 1996b) intended to apply to the Oregon portion of the Southern Oregon/Northern California Coasts ESU and the Oregon Coast ESU. For endangered status, the proposed criterion was that 3-year average abundance of wild spawners in a single Gene Conservation Group (GCG) within the ESU falls below a population threshold derived from one of three models used in the report. For threatened status, several optional criteria were used, and the ESU would be listed as threatened if any single criterion was met. The criteria were (1) abundance in any GCG is less than three times the endangered level for that GCG, (2) analysis of trend indicates that abundance in any GCG will fall below the endangered level within 6 years, or (3) for the Northern GCG only, a substantial number of adjacent basins within the GCG are below the endangered level, even if overall abundance is above the threatened level. In considering the value of these proposed recommendations, the BRT noted that the report was a preliminary draft, and the criteria were not reviewed or approved by the entire Science Team. There are several problems with the criteria. First, the endangered criterion considers only abundance information and the threatened criteria consider only abundance and short-term trend, not other risk factors identified in this report. Second, the abundance criteria are derived from only one of three model approaches considered by the Science Team, and are clearly lower than those that would be derived from one of the other approaches. Third, the model upon which the criteria were based is itself based on freshwater production parameters estimated from a variety of studies, with no means of adjusting parameters to the specific conditions of local basins, and the model does not incorporate any measure of uncertainty in parameters or model structure. Fourth, the critical model results depend heavily on strong compensation at low population levels, but the dynamics of very small populations are poorly understood and unpredictable. For these reasons, these proposed criteria were not a major determinant for the conclusions reached by the BRT.

In November 1996, NMFS Northwest and Southwest Fisheries Science Centers sponsored a symposium/workshop on "Assessing Extinction Risk for West Coast Salmon" (Seattle, 13-15 November 1996). The objective of the workshop was to evaluate scientific methods for assessing various factors contributing to extinction risk of Pacific salmon populations. Following public presentations and discussions of risk assessment issues, a panel of 10 scientists met to provide recommendations to NMFS regarding best methods for conducting assessments of extinction risk for Pacific salmon under the ESA. The panel was asked to provide advice both on short-term improvements in assessment methods and on longer-term research to improve assessment methods and to improve the information base supporting assessments. The final report on panel recommendations will not be available until early 1997, but a preliminary summary of key recommendations was considered by the BRT in this review. Most of these recommendations require long-term development of improved methods, and thus could not be applied in this review.

DISCUSSION OF ESU DEFINITIONS

Lower Columbia River Coho Salmon

One Lower Columbia River (LCR) population that received little attention during the 1994 BRT meeting was Sandy River coho salmon above Marmot Dam. ODFW staff have suggested that this population, like late-run coho salmon from the Clackamas River, may represent the last remnants of native, lower Columbia River coho salmon. To facilitate our consideration of this population, ODFW provided a report summarizing the history and status of Sandy River coho salmon, with emphasis on the population(s) above Marmot Dam (Frazier and Murtagh 1995). The following is a brief summary of the report, with additional comments on the population by K. Kostow (ODFW).

The Sandy River has a long history of multiple dams and hatcheries. Most notably, Marmot Dam (RM 30) was installed in 1912, and the current Sandy Hatchery began operation in 1950 on Cedar Cr., below Marmot Dam. Extensive planting of Sandy Hatchery coho salmon (which are early timed) above Marmot Dam began in 1961, and was terminated in 1988 (fed fry) and 1991 (unfed fry).

Based on various indicators of population abundance and composition, such as Marmot Dam counts, harvest rates, estimated adult contribution from juvenile plants, spawner and juveniles surveys, scale analysis, etc., Frazier and Murtagh reached several conclusions about the status of coho salmon above Marmot Dam: 1) coho salmon above Marmot Dam are presently at stable population levels, 2) natural production does occur, 3) straying of Sandy Hatchery coho above the dam is low, and, 4) hatchery supplementation may have advanced the peak run timing over Marmot Dam from November (1960-66) to October (at present). They also asserted that present fisheries management practices were likely to benefit naturally produced coho in the upper Sandy Basin.

Frazier and Murtagh did not discuss the probable origin of the naturally spawning population in the upper Sandy River--whether they are essentially naturally reproducing Sandy Hatchery fish, or whether they represent the ancestral Sandy River population. BRT members did, however, discuss this question with K. Kostow (ODFW, pers. comm., Nov. 26, 1996) at some length. Kostow believes that coho salmon in the upper Sandy River (and Clackamas River, for that matter) may have had hatchery influence, but still represent the ancestral populations in both basins. She bases this judgement, in part, on the fact that both Sandy and Clackamas River coho salmon are genetically distinct from each other and from other LCR populations. She argues that the distinctiveness of these and other LCR populations indicates that they have maintained at least some of their uniqueness despite the widespread hatchery production, and therefore still represent ancestral populations.

With respect to run timing, Kostow agrees that it has been altered (become earlier in the upper Sandy, later in the upper Clackamas), but argues that both are still within the historical range of LCR coho. She does not, however, agree with the view raised by NMFS in its review of LCR coho salmon (Johnson et al. 1991) that all early-timed fish are hatchery fish, because, she argues, there were naturally early populations in the LCR prior to widespread hatchery propagation.

New Genetic Data

We examined the genetic relationships of coho populations from the lower Columbia River and southwest Washington coast by analyzing an allozyme data set consisting of 41 samples (Table 2). The data set included 29 samples from the 1994 status review (Weitkamp et al. 1995), and 12 new samples collected by NMFS, ODFW, and WDFW. Among the new samples were several from populations of the upper Chehalis River, North River, and Bear River. New samples were also taken from the Clackamas and Sandy Rivers. In the analysis presented below, we used 53 gene loci to compute Cavalli-Sforza and Edwards' chord distances (Cavalli-Sforza and Edwards 1967) between all pairs of samples. The electrophoretic procedures, list of loci, and method of genetic distance computation were as described in the status review. We used two methods to depict genetic relationships. First, we constructed a dendrogram based on the pairwise genetic distance values (Fig. 1). We used the unweighted pair-group method analysis (UPGMA) with arithmetic averaging. Second, we performed a multidimensional scaling (MDS) analysis of the genetic distances (NTSYS-pc; Rohlf 1993). MDS provides a means of representing genetic relationships in two or three dimensions; in contrast, a dendrogram provides a one-dimensional view of the data. We also computed a minimum spanning tree (MST) of the genetic distance matrix. The MST consists of connections between each sample and its nearest genetic neighbor. When superimposed on an MDS plot, an MST can be useful to detect distortions - pairs of points which look close together in the plot but are actually not. Results of the MDS and MST are shown in Figure 2.

Several genetic groups of samples were identified in both the dendrogram and MDS plot (Figs. 1 and 2). The most genetically distinct group was a cluster of lower Columbia River samples from Oregon. The sample from Hardy Creek (23) located in Washington near Bonneville Dam also clustered with this group of samples. All of the samples from populations in the Sandy River (19, 21, and 22) and Sandy River Hatchery (18 and 20) were in this group. Each of the Sandy River samples was quite genetically distinct from other samples. However, because genetic variability among the Sandy River samples was also quite large, the genetic relationship of Sandy River coho salmon and other lower Columbia River populations is not clear.

A second major cluster contained samples from lower Columbia River populations in Washington. Three samples from lower Columbia River populations in Oregon were also in this group: Clatskanie River (6) and the 1989 and 1990 brood years from Clackamas River (13 and 14). In contrast, the sample of the 1994 brood year from the Clackamas River (15) was included in the first genetic group described above.

A third major cluster contained samples from rivers which enter Grays Harbor in southwest Washington. These included samples from the Chehalis (31 to 39) and Humptulips (41) Rivers.

A fourth genetic group contained samples from rivers which enter Willapa Bay in southwest Washington. These included the sample from the North River (30) as well as the samples from Naselle (27), Nemah (28), and Willapa (29) Hatcheries.

The pattern of genetic relationships was generally consistent between the dendrogram and MDS plot. Two exceptions are worth noting. One difference was the positions of the Oakville fishery sample from the upper Chehalis River (40) and the sample from the Bear River of Willapa Bay (26). In the dendrogram, these two samples grouped together and then clustered with lower Columbia River samples. In the MDS plot, the minimum spanning tree also showed a connection between these two samples. However, in contrast to the dendrogram, the MST indicated genetic affinity between the Oakville fishery sample and the sample from the upper Chehalis taken at Rochester (36) and between the Bear River sample and the Naselle Hatchery sample (27). A second difference between the dendrogram and the MDS plot was the position of the 1982 brood year Grays Hatchery sample (4). This sample was an outlier in the dendrogram, but clustered with other lower Columbia River samples in the MDS plot.

In cooperation with the Quinault Fisheries Division, NMFS scientists collected a sample of 1995 brood year coho salmon from the north fork of the Moclips River. The sample consisted of 37 juvenile fish. We examined this sample as part of a genetic data set that contained 98 samples from populations of coho salmon from the Oregon coast, lower Columbia River, Washington coast, and Puget Sound. An analysis of genetic distance values between all pairs of samples was performed. The sample from the Moclips River was an outlier to the entire set of samples in both a dendrogram and MDS analysis (not shown). The genetic distance between the Moclips River sample and its nearest genetic neighbor, a sample from the Queets River, was considerably larger than between any other pairs of nearest neighbors. The lack of genetic affinity between samples from Moclips River and other populations could be caused by any number of factors, including a very small population size in the Moclips River or by non-representative sampling.

CONCLUSIONS OF ESU DEFINITIONS

After re-examining environmental and life-history information and examining new genetic information described above, the BRT reached the following three conclusions: 1) splitting the previously identified Lower Columbia River/Southwest Washington coast ESU into two ESUs was most consistent with available information. This spitting creates two ESUs--a Lower Columbia River ESU and a Southwest Washington coast ESU, and results in a total of seven coho salmon ESUs, with boundaries as show in Figure 3. 2) Coho salmon from the Moclips and Copalis Rivers are part of the Southwest Washington coast ESU. 3) There is insufficient information to determine whether coho salmon above Marmot Dam on the Sandy River are still part of the historic Lower Columbia River ESU. The BRT generally felt that there was at least as much uncertainty regarding this population's relationship to the ESU as there was for late-run Clackamas River coho salmon. No new information was developed that might help resolve uncertainty about the Clackamas River run.

DISCUSSION OF EXTINCTION RISK FACTORS

In this section, we discuss important new information and analyses for several risk factors (hatchery production and genetic risks, habitat conditions, spawner size, population abundance, and population trends and production) on a coastwide basis to allow comparison of specific factors across ESUs. The following section summarizes these factors for each ESU, and draws conclusions regarding the degree of extinction risk facing each ESU based on this new information as well as that in Weitkamp et al. (1995).

Hatchery Production and Genetic Risks

The following discussion is based on the summary table of artificial propagation factors by basin (Appendix Table 1).

Numbers of hatcheries each ESU

In general, there is a latitudinal trend in the number of coho salmon hatcheries along the west coast, with more hatcheries in the northern than in the southern ESUs, and some Columbia River and Puget Sound/Strait of Georgia tributaries have more than one hatchery. Because the majority of hatchery releases occur in-basin, the naturally spawning populations in basins that contain hatcheries are the most likely to have hatchery influence. Similarly, because most out-of-basin releases occur in adjacent basins, naturally spawning populations in basins that don't themselves contain hatcheries but are near basins that do are more likely to have hatchery impacts than populations that are farther away from hatcheries. The production capacity of hatcheries also follows a latitudinal trend, with many northern hatcheries capable of producing several millions smolts each year, while more southern hatcheries produce tens or hundreds of thousands of fish annually.

Number of fish planted and stocks used

We have summarized various statistics about the number and types of fish planted into each basin (Appendix Table 1). This information consists of the number of stocks planted, the total number of fish released, the percentage of releases that consisted of "native" fish (stocks whose name is either the basin or subbasin name), and the percentage of releases that consisted of smolts (as opposed to fry). Other things being equal, the more fish that are planted, the more likely natural populations are to be impacted by hatchery fish. Similarly, the more genetically similar hatchery fish are to natural populations they spawn with, the less change there will be in the genetic makeup of future generations. We included the percentage of smolts released because a) smolts generally spend less time in freshwater before migrating to sea, reducing the opportunity for interactions with naturally produced fish, and b) hatchery fish released as smolts survive at a rate much higher than hatchery fish released as fry.

Hatchery releases listed in Appendix Table 1 are separated into two time periods, 1950-85 and 1986-present, to emphasize changes in planting practices that occurred in the 1980s. For many basins, the number of stocks planted, the size and frequency of annual releases, and the percentage of smolts releases is quite different between the two periods (fewer stocks, fewer fish planted, higher percentage smolts in later years), in response to wild fish policies in Oregon and Washington. Other basins, however, have seen dramatic increases in the number of fish planted.

Natural production

Although the absolute number of fish planted in a basin is related to the potential impact those fish will have on natural populations, the number of fish released relative to the size of the natural population is, in some ways, a more important predictor of hatchery impacts. For example, a plant of 10,000 fish in a natural population of 1,000 fish obviously has a much greater potential impact than the same plant on a population of 100,000 fish. The BRT has provided two measures of natural abundance--recent natural spawner abundance and miles of habitat--for each basin. These measures are provided to help evaluate the relative number of planted fish, and the relative "health" of current populations. For example, a key question is, based on the number of fish and the miles of habitat, does there appear to be sufficient vacant habitat in which hatchery fish could survive, or are large numbers of natural fish already occupying that habitat? Miles of habitat are used as a gross substitute for data on carrying capacity of habitats, which are not available coastwide.

One complicating factor in estimating relative size of hatchery releases, particularly those that occurred several decades ago, is that the size of many natural populations have undergone dramatic declines. Consequently, although the frequency and number of fish released in many basins has been declining, so has the natural population that would be impacted. Whether declines in the number of fish planted and the size of natural populations have kept pace with each other remains to be determined.

Hatchery fish spawning naturally

ODFW argued that, in the status review, we overestimated the risks to Oregon coast populations because straying of hatchery fish to natural spawning areas was only a significant factor in a few, isolated areas (Nickelson 1995, ODFW 1995). In order to address this comment, the BRT assembled data on the proportion of hatchery fish that spawn naturally in each ESU, based on scale analysis, CWT recoveries, or other marks (fin clips) (Table 3).

Although such data were unavailable for many basins, particularly in California and on the Olympic Peninsula, data that were available indicated that the proportion of hatchery fish that spawned naturally was high in many basins. This was particularly true for many basins along the Oregon coast, in southwest Washington, and some basins in Puget Sound, especially near net-pens, and the percentage is assumed to be near 100% for many Columbia River tributaries, with the exception of Sandy and Clackamas Rivers.

After reviewing NMFS' compilation of data on Oregon coast hatchery fish identified in natural spawning areas by scale analysis, ODFW staff argued that it failed to represent actual trends in straying within basins (T. Nickelson, S. Jacobs, J. Nicholas, Pers. comm., Aug. 1996). They felt that the data presented were upwardly biased because 1) locations where scales were collected did not represent conditions in the entire basin, and 2) some scales may have been misidentified. ODFW also provided a new dataset that they felt better represented actual conditions (Nickelson and Jacobs 1996). In many cases, the percentage of hatchery fish identified in natural spawning areas is lower is the new dataset, and sites with particularly high percentages are identified as hatchery sites (Table 4).

The percentage of hatchery fish spawning naturally also is an indication of the relative influence of hatcheries on natural populations, and the size of hatchery releases versus the size of the impacted natural population. For example, although only 5-6,000 fish have been released into Scott Cr. in central California annually, these fish made up 72% of returning adults in 1994. These high rates suggest substantial risks to the sustainability of those populations based strictly on numbers, as described above, and potentially large genetic risks if these stray hatchery fish are able to successfully reproduce.

Spawn timing

An additional comment the BRT received from ODFW concerning the assessment of risks from artificial propagation in the status review was that there is substantial and deliberate separation of spawn timing of natural and hatchery populations of coho salmon along the Oregon coast, and that earlier-spawning hatchery fish have little reproductive success because the earlier timing makes their redds prone to destruction by early fall storms. ODFW argued that this difference in timing was large enough that even if hatchery fish strayed to spawning grounds, they would not be spawning with natural fish and therefore would not have permanent genetic impacts.

To evaluate this claim, the BRT examined information on spawn timing for hatchery and natural populations in all ESUs (summarized in Appendix Table 1). Advancement of spawn timing is a common practice in coho salmon to allow extended fishing opportunity and separation of hatchery and wild populations. However, one of the requirements of advancing spawn timing is that a hatchery has more fish than it needs and therefore may select spawners from the earlier portion of the run. For most California hatcheries, returns to the hatchery are generally small enough that most or all fish have to be spawned to meet eggtake, and therefore fish from throughout the run contribute to the next generation. Consequently, although the BRT has no timing information for both hatchery and natural populations from the same California basins, it is expected that hatchery spawn timing has not changed dramatically at California hatcheries, and still greatly overlaps natural spawn timing.

The BRT generally did not find large timing differences for basins with both hatchery and natural spawn timing data. Although spawn timing of hatchery and naturally spawning fish was clearly different in some basins, there was considerable overlap in recorded spawn timing in others. Furthermore, for those Oregon basins in which there were apparent differences, fish continued to return to the hatchery after spawning was completed, suggesting that the hatchery populations were capable of spawning (and presumably did spawn naturally) later than the times reported by the hatchery.

In October 1996, ODFW provided new information on timing of naturally spawning fish identified as of hatchery or natural origin based on scale analysis, from selected areas known to high percentages of hatchery fish (Jacobs and Nickelson 1996). This timing data, most of which came from the Nehalem River, indicated some separation of hatchery and wild spawn timing. This difference in Nehalem hatchery and wild spawn timing is consistent with the BRT's analysis, which indicated clear differences between the two. However, it is unclear whether such separation occurs in other basins, particularly those identified as having less separation in hatchery and wild spawn timing.

Other Factors

One key risk factor that has received relatively little attention is the relative reproductive success of naturally spawning hatchery coho salmon. Whether these fish successfully reproduce at low, moderate or high rates compared to natural fish is a major, but poorly understood, factor in determining their effects on natural populations. Based on spawner-to-spawner ratios, ODFW estimated that stray coho salmon from Oregon Aquafoods (Yaquina Bay), which included a high proportion of Puget Sound stocks, had a reproductive success rate of 10% of natural fish (OCSRI 1996 (Attachment II, Appendix 4)). In comparison, they estimated that fish from Cole Rivers Hatchery, which uses only native stock but has been domesticated for approximately 15 years, were 50% as successful at reproducing as wild fish, and hatchery fish from other Oregon coast hatcheries were 30% as successful. The accuracy of these estimates remains to be determined.

Habitat Conditions

Habitat Requirements of Coho Salmon

Coho salmon spend their first 15-20 months in streams and rivers and are therefore particularly vulnerable to adverse impacts of past and current land use practices. Reeves et al. (1989) defined physical habitat requirements for coho salmon at each freshwater life history stage. With the exception of spawning habitat, which consists of small streams with stable gravels, summer and winter freshwater habitats most preferred by coho salmon consist of quiet areas with low flow, such as backwater pools, beaver ponds, dam pools, and side channels. Habitats used during winter generally have greater water depth than those used in summer, and also have greater amounts of large woody debris (LWD). Production of wild coho salmon smolts in streams on the Oregon Coast is probably limited by the availability of adequate winter habitat (Nickelson et al. 1992).

Habitat factors other than physical features, such as nutrient and food availability, limit production of juvenile coho salmon but the procedures for identifying these biological factors are not well developed, and biological habitat factors are not commonly evaluated by fishery managers.

Historical Conditions

The role that large woody debris plays in creating and maintaining coho salmon spawning and rearing habitat in all sizes of streams has been recognized for only the past 25 years. Before this time, up to 90% of the funds for fish-habitat enhancement went for removal of wood debris in streams (Sedell and Luchessa 1982).

Descriptions of pre-development conditions of rivers in Washington and Oregon that had abundant salmonid populations suggest that even big rivers had large amounts of instream LWD, which not only completely blocked most rivers to navigation but also contributed significantly to trapping sediments and nutrients, impounding water, and creating many side channels and sloughs (Sedell and Froggatt 1984, Sedell and Luchessa 1982). Many streams consisted of a network of sloughs, islands, and beaver ponds with no main channel. For example, portions of the Willamette River reportedly flowed in five separate channels, and many coastal Oregon rivers were so filled with log jams and snags they could not be ascended by early explorers. Most rivers in coastal Washington and Puget Sound were similarly blocked by large woody debris, snags, and instream vegetation. Sedell and Luchessa (1982) compiled a partial list of major rivers that were impassable for navigation in the mid-1800s because of large (100-1500 m-long) log jams; this list included 11 rivers in Oregon and 16 in Washington.

Besides clearing rivers for navigation, extensive "stream improvements" were accomplished to facilitate log drives. These activities included blocking off sloughs and swamps to keep logs in the mainstream and clearing boulders, trees, logs, and snags from the main channel. Smaller streams required the building of splash dams to provide sufficient water to carry logs. Scouring, widening, and unloading of main-channel gravels during the log drive may have caused as much damage as the initial stream cleaning. Stream cleaning continued through the mid-1970's in many areas, not only for flood control and navigation but as a fisheries enhancement tool as well. Debris in streams was viewed as something that would either impede or block fish passage and as a source of channel destruction by scour during storm-induced log jam failures.

Habitat Modification

The past destruction, modification, and curtailment of freshwater habitat for steelhead was reviewed in the "Factors for Decline" document published as a supplement to the notice of determination for West Coast Steelhead under the ESA (NMFS 1996). Since the range of coho salmon and steelhead overlap extensively, this document serves as a catalog of past habitat modification for coho salmon as well as steelhead. NMFS (1996) documented habitat losses within the range of west coast coho salmon due to: (1) hydropower development (juvenile and adult passage problems); (2) water withdrawal, conveyance, storage, and flood control (resulting in insufficient flows, stranding, juvenile entrainment, instream temperature increases); (3) logging and agriculture (loss of LWD, sedimentation, loss of riparian vegetation, habitat simplification); (4) mining (gravel removal, dredging, pollution); and (5) urbanization (stream channelization, increased runoff, pollution, habitat simplification). Lichatowich (1989) also identified habitat loss as a significant contributor to stock declines of coho salmon in Oregon's coastal streams.

A number of authors have attempted to quantify overall anadromous fish habitat losses in areas within the range of west coast coho salmon. Gregory and Bisson (1996) stated that habitat degradation has been associated with greater than 90% of documented extinctions or declines of Pacific salmon stocks. It has been reported that up to 75% and 96% of the original coastal temperate rainforest in Washington and Oregon, respectively, has been logged (Kellogg 1992), and that only 10-17% of old-growth forests in Douglas-fir regions of Washington and Oregon remain (Norse 1990, Speis and Franklin 1988). California has reportedly lost 89% of the state's riparian woodland to various land use practices (Kreissman 1991). Within California, Fisk et al. (1966) stated that over 1,600 km of streams had been damaged or destroyed as fish habitat by 1966. Approximately 80-90% of the original riparian habitat in most western states has been eliminated (NMFS 1996). For example, Edwards et al. (1992) reported that 55% of the 43,000 stream kilometers in Oregon were moderately or severely affected by non-point source pollution.

Large, deep-pool habitats are a particular requirement of high quality stream habitat for coho salmon. FEMAT (1993) reported that there has been a 58% reduction in the number of large, deep pools on national forest lands within the range of the northern spotted owl in western and eastern Washington. Similarly, there has been as much as an 80% reduction in the number of large, deep pools in streams on private lands in coastal Oregon (FEMAT 1993). Overall, the frequency of large pools has decreased by almost two-thirds between the 1930s and 1992 (FEMAT 1993, Murphy 1995).

Schmitt et al. (1994) pointed out that coho salmon make extensive use of estuarine habitat on migration to the sea and that overall losses since European settlement, by area, of intertidal habitat were 58% for Puget Sound in general and 18% for the Strait of Georgia. Four river deltas (the Duwamish, Lummi, Puyallup, and Samish) have lost greater than 92% of their intertidal marshes (Simenstad et al. 1982, Schmitt et al. 1994). Dahl (1990) reported that over 33% of wetlands in Washington and Oregon have been lost and that much of the remaining habitat is degraded.

The 1992 Washington State Salmon and Steelhead Stock Inventory identified numerous land use practices or habitat factors that have had a detrimental impact on coho salmon habitat for each of 90 recognized coho salmon stocks in Washington (WDF et al. 1993). Dominant land-use practices and habitat factors cited in this report differ to some extent between coho salmon ESUs, with the Puget Sound/Strait of Georgia ESU incurring greatest impact from urbanization and agricultural practices, the Olympic Peninsula ESU incurring greatest impact from forest practices, and the Lower Columbia River/Southwest Washington Coast ESU incurring greatest impact from forest and agricultural practices (WDF et al. 1993).

Weitkamp et al. (1995) pointed out the rarity of specific quantitative assessments of coho salmon habitat degradation and its causes. Two studies addressing this topic have subsequently appeared. Beechie et al. (1994) estimated a 24% and 34% loss of coho salmon smolt production capacity of summer and winter rearing habitats, respectively, in the Skagit River, Washington since European settlement. Beechie et al. (1994) identified the three major causes for these habitat losses, in order of importance, as hydromodification, blocking culverts, and forest practices. Similarly, McHenry (1996) estimated that since European settlement, Chimacum Creek, Washington (northwest Puget Sound) had lost 12%, 94% and 97% of its spawning, summer rearing, and winter rearing habitats for coho salmon, respectively. McHenry (1996) stated that these habitat losses were due to logging, agricultural clearing, channelization, drainage ditching, groundwater withdrawal, and lack of woody debris.

Logging, agriculture, urbanization, grazing, and mining have led to large reductions in essential summer and winter rearing habitat for coho salmon (backwater pools, beaver ponds, side channels, off-channel areas, deep lateral scour pools, dam pools, and stream margins where LWD and boulders form deep pockets of water) in Washington, Oregon, and northern California. Loss of deep pool habitat make coho salmon vulnerable to high instream summer temperatures, winter flood events, lowered water quality, and predation by fish and birds due to lack of cover.

Spawner Size

When the BRT originally evaluated risks faced by coho salmon ESUs in 1994, the rapidly declining size of coho salmon in the Puget Sound/Strait of Georgia ESU was considered to be a significant risk factor because it could seriously affect the long-term health of populations. This might occur through decreased fecundity, fewer and shallower redds, decreased probability of successfully migrating, and decreased ability of populations to produce large individuals.

Old Spawner Size Data

In Puget Sound, the average weight of adult fish caught in terminal fisheries decreased from approximately 4 kg to 2.5 kg between 1972 and 1993. This decline was much steeper than declines in size observed in other areas. Length data from Big Beef Creek and the Deschutes River, two natural production streams that have large components of hatchery strays, were also examined, and the data indicated decreases from 60-65 cm FL in 1978-79 to less than 56 cm in 1991-92. The only 1994 data the BRT had at the time of the status review, from test fisheries near Apple Tree Cove, indicated a clear increase in size in 1994 over previous years.

Comments on Adult Size

The comments received from comanagers regarding declining adult Puget Sound coho salmon size were that: 1) the rapid size decline was restricted to hatchery fish, and if naturally spawning fish had declined in size, it was much slower and at rates comparable to areas outside Puget Sound; and 2) increases in size in 1994 and 1995 indicate that populations have not lost their ability to produce large fish.

New Data

Since the 1994 BRT meeting, the BRT has received and analyzed new size data, which are summarized here. With regards to the second comment from the comanagers, the BRT has updated all in-river fisheries size data to include the 1994 and 1995 data (Fig. 4-7). The size of coho salmon caught in these 2 years is larger than the previous several years, but the overall trends are still clearly downwards. The BRT also has data from Canadian catches that includes 1994 and 1995 weights, which also exhibit upward trends in these last 2 years but remain downwards overall (Fig. 8). For many Puget Sound and Strait of Georgia datasets, adult size decreased in the 1970s and 1980s, and size in 1993 was the lowest on record.

The BRT also tried to determine whether rapidly declining size is restricted to hatchery stocks, which WDFW and NWIFC (1996) claim is due solely to higher harvest rates experienced by hatchery populations and by hatchery practices. Unfortunately, adult size is not regularly measured during WDFW or tribal escapement surveys, so there are no good, long-term Puget Sound data sets for natural populations. Black Creek, on Vancouver Island, is thought to have almost no hatchery influence, and spawners have been measured annually since 1977. Although the overall trend in size for this population is downward, the trend is not significant and exhibits high intra- and interannual variability, perhaps due in part to variation in the proportion of the run that migrates outside the Strait of Georgia compared to those that remain in inside waters (J. Ervin, CDFO, Pacific Biological Station, Nanaimo, pers. comm., Sep. 17, 1996)

The BRT also examined trends in several Puget Sound systems managed for natural production (Skagit and Stillaguamish Rivers), and results of these analyses were mixed. The BRT received 8 years of spawner length data from the Skagit River, converted it to weight using 2 formulas (Marr 1943, Holtby and Healey 1986), and compared it to the updated in-river catch size dataset, and to in-river catch occurring after Nov 15, when primarily naturally spawning fish are supposed to dominate the catch (Fig. 9). All three trends show similar patterns, although the spawner data does not go back far enough to capture the large size decline between 1978 and 1984, and the number of fish caught after Nov. 15 becomes quite small, leading to highly variable average sizes in some years. Generally, although the long-term size trends for coho salmon from the Skagit and Stillaguamish Rivers are downwards, the trends in some of the hatchery-managed systems (Puyallup and Duwamish Rivers) are steeper (Fig. 5).

Finally, WDFW has examined long-term (1940-93) trends in fecundity for four Puget Sound hatchery populations (Skykomish River, George Adams, Voight Creek, and Minter Creek). In all cases, trends were significantly negative, and ranged from a decrease of 12 to 39 eggs per year.

In conclusion, there has been a rapid decline in adult size of coho salmon caught in the Puget Sound/Strait of Georgia area. Fecundity at hatcheries has also declined, suggesting that should declines also be occurring in natural spawning populations, the risks to long-term sustainability are very real. There are few direct data for naturally spawning populations in the area. Data from French Creek indicate a small and statistically insignificant decrease in size, while data from the Skagit and Stillaguamish rivers exhibit clear declines which are intermediate to the range of those observed in Puget Sound hatchery-dominated populations.

Population Abundance

1) Central California coast ESU

Since the status review, further stream surveys have been conducted to evaluate distribution and abundance of coho salmon in this ESU. A large number of streams were resurveyed in 1995-1996 for presence/absence of coho salmon. Most surveys targeted juveniles, but some focused on adults. These surveys allowed a comparison with results from a previous study (Brown et al. 1994) that estimated the proportion of streams historically recorded as supporting coho salmon populations that currently have coho salmon. The proportion of streams with coho salmon present was higher in the more recent surveys (57% vs. 47%), although it is not clear whether this represents an improvement in status of coho salmon or simply differences in sampling methods. Preliminary estimates of 1996 returns from CDFG suggest improved escapement of coho salmon, but no firm numbers were available at the time of this review.

2) Southern Oregon/Northern California coasts ESU

For the Southern Oregon/Northern California Coasts ESU, the BRT has received revised estimates of terminal run size at Huntley Park (lower Rogue River; T. Nickelson, ODFW, Pers. comm. 15 May 1996) and upstream passage at Gold Ray Dam (Anderson 1996) in the Rogue River Basin. The 1991-1995 geometric mean terminal run size estimated at Huntley Park is 1,420 natural coho salmon, with a corresponding ocean run size (based on harvest rate estimates for Cole Rivers Hatchery stock) of 1,642 (Appendix Table 2). In addition, there have been an average of 3,000 hatchery fish in the terminal run. For comparison, historical run size estimates for the late 1800s and early 1900s averaged above 50,000, but declined to less than 10,000 by the 1920s (ODFW 1995a). The 1995 run was the largest since 1988, but was estimated to be 70% hatchery production (10,047 hatchery and 4,221 natural fish estimated at Huntley Park). Fish passage counts at Gold Ray Dam include fish returning to Cole Rivers Hatchery and to natural spawning areas in the upper Rogue River Basin. Counts of natural fish at the dam have fluctuated widely, ranging in the last 10 years from zero (1992) to above 3,000 (1988, 1994, 1995). Natural escapement to the upper basin was extremely low during the late 1960s and early 1970s, recovering only after production started at Cole Rivers Hatchery in the late 1970s. This fact, along with a strong correlation between natural and hatchery escapement (see discussion of trends below) suggests that natural coho salmon in the upper basin may largely be progeny of hatchery strays. Satterthwaite (1996, p. 1) concluded that recent increases in natural fish passing Gold Ray Dam are likely the result of increased spawning by stray hatchery fish, lower ocean harvest rates, and improved ocean survival.

The BRT has also received general comments by ODFW staff on distribution and abundance of coho salmon in the Oregon portion of this ESU (Confer 1996; Satterthwaite 1996; Vogt 1996). Data for assessing spawning activity in Rogue River tributaries and other streams in the ESU are quite limited, and mostly reflect sporadic adult and juvenile survey efforts by ODFW and USFS staff in the region. More surveys have been conducted in recent years, and the coastal SRS survey methodology will be expanded to areas south of Cape Blanco beginning this year. Within the Rogue River Basin, low to moderate numbers of adult and juvenile coho salmon have been found in numerous tributaries. Interpretation of some of the juvenile surveys has been confounded by prior fry releases or hatchbox programs that make it difficult to assess natural production, but there are several streams in the basin with regular observations of significant natural spawning. Outside the Rogue River Basin, the Oregon portion of this ESU has very limited coho salmon habitat, due to steep gradients with little overwintering habitat in lower streams. Of these streams, the Elk River has the best habitat, and is the only stream outside the Rogue where there have been consistent, recent observations of coho salmon, with escapement of about 100-200 fish. This is considerably below historical abundance estimates (1,500 fish in the 1927-28 season)(Confer 1996). Coho salmon are occasionally observed in other streams during spawner surveys or broodstock collection for chinook salmon. Over the past 10 years, a total of 5 coho salmon have been observed in Hunter Creek and the Pistol River. Higher numbers have been observed in the Chetco River (23 fish in 7 years) and Winchuck River (21 fish in 7 years). Because of very limited habitat, these streams probably never supported large populations. Confer (1996) suggests that the Chetco and Winchuck Rivers might be able to sustain populations of fewer than 200 coho salmon.

Information on presence/absence of coho salmon in northern California streams has been updated since the study by Brown et al. (1994) cited in the status review. More recent data (Table 5) indicates that the proportion of streams with coho salmon present is lower than in the earlier study (52% vs. 63%). In addition, the BRT received updated estimates of escapement at the Shasta and Willow Creek weirs in the Klamath River Basin, but these represent primarily hatchery production and are not useful in assessing the status of natural populations.

3) Oregon Coast ESU

For the Oregon Coast ESU, the BRT has received updated estimates of total natural spawner abundance based on stratified random survey (SRS) techniques, broken down by ODFW's Gene Conservation Groups (GCGs) and by smaller geographic areas (Nickelson 1996). These data are presented in Table 6. Total average (5-year geometric mean) spawner abundance for this ESU is estimated at about 45,000 (Appendix Table 2), slightly higher than the estimate at the time of the status review. Corresponding ocean run size is estimated to be about 72,000; this corresponds to less than one-tenth of ocean run sizes estimated in the late 1800s and early 1900s, and only about one-third of those in the 1950s (ODFW 1995). Total freshwater habitat production capacity for this ESU is presently estimated to correspond to ocean run sizes between 141,000 under poor ocean conditions and 924,000 under good ocean conditions (OCSRI Science Team 1996b). Present abundance is unevenly distributed within the ESU, with the largest total escapement in the relatively small Mid/South Coast Gene Conservation Group (GCG), and lower numbers in the North/Mid Coast and Umpqua GCGs (Appendix Table 2).

4) Lower Columbia River

Updated abundance information is summarized in Appendix Table 2. The main potentially native, natural production of coho salmon in this ESU is in the Clackamas River and possibly the Sandy River. For all but the Clackamas River, it is nearly impossible to determine how much of the production in the populations is the result of natural production and what the effects of hatchery practices have been on the populations.

Natural production occurs above Marmot Dam in the Sandy River. Hatchery fry, presmolts, and adult spawners released through 1988 were intended to seed the habitat above Marmot Dam. From 1988 through 1991, unfed fry releases were continued with an average of about 92,000 Sandy stock STEP unfed fry released annually (Frazier and Murtagh 1995). The 1994 spawning run, therefore, was the first to result solely from natural production.

5) Southwest Washington

Native, naturally-produced coho salmon in this ESU occur primarily in the Chehalis River Basin. There is recent evidence of several thousand naturally produced coho salmon in the North River in Willapa Bay, but this is only from a single survey (WDFW 1996a).

Abundance information is summarized in Appendix Table 2. Escapement and run size for Grays Harbor are for adjusted wild escapement, as estimated by the Quinault Indian Nation (NWIFC 1996b). They calculated adjusted wild escapement by subtracting hatchery strays, in years where stray rate data are available, and spawning escapement attributable to off-station hatchery smolt releases from natural escapement. In years when no hatchery stray rate data are available, no adjustment was made. The contribution of off-station smolt releases was calculated assuming they survived at 30% of the rate that on-station releases did. No adjustment was made to account for hatchery fry releases. The assumption of 30% relative survival of off-station smolt releases may introduce a bias in the estimates; other coho salmon studies have estimated that off-station smolts survival is 80% that of on-station releases (Johnson et al. 1990).

WDFW and NWIFC (1996) provided recent updates and analysis of southwest Washington populations. They concluded that early and late-run coho salmon belong to the same population, harvest management goals have been appropriate, and that although hatchery production has been extensive throughout the Chehalis River Basin, the system is naturally highly productive and hatchery production may provide a minor portion of total production from the system in some years.

6) Olympic Peninsula

The BRT has received updated information on terminal run size and spawning escapement for Olympic Peninsula streams from the coastal tribes (NWIFC 1996b, 1996c) and also received estimated ocean exploitation rates for Queets River coho salmon for 1994. Assuming that Queets River stock productivity and trends are representative of the entire ESU, and that ocean exploitation rates were approximately the same in 1995 as in 1994, the BRT calculated pre-harvest abundance (ocean run size) and recruits-per-spawner for Olympic Peninsula stocks. Run sizes to streams in the Strait of Juan de Fuca were expanded using estimated Puget Sound ocean exploitation rates. Ocean run size and spawning escapement were both down dramatically in Olympic Peninsula stocks in 1994 (Fig. 10). Spawning runs rebounded somewhat in 1995, but the low run size in 1994 brought the geometric means down for all stocks in this ESU (Appendix Table 2). This is in stark contrast to Puget Sound, where 1994 spawning escapement was at record levels for many stocks. The 5-year geometric mean of natural spawning escapement for the Olympic Peninsula ESU was 21,700 with an estimated pre-harvest abundance of 41,700.

7) **Puget Sound / Strait of Georgia**

Since the status review, the BRT has updated estimates of spawning escapement and Puget Sound harvest for Puget Sound stocks in 1993, 1994, and 1995 (NWIFC 1996a). The BRT also received escapement estimates for 29 natural populations on Vancouver Island and the Strait of Georgia (Foy et al. 1995). However, the Canadian populations surveyed are not comprehensive and cannot be used to assess overall abundance in the British Columbia portion of this ESU. Within the Puget Sound portion of this ESU, escapement to natural spawning areas in 1994 was the highest since 1965 (Fig. 11). Spawning escapement in 1995 was somewhat lower, but still higher than the long-term mean. Total spawning escapement peaked in 1971, but the proportion of hatchery returns was higher then. Natural escapement management areas within Puget Sound showed a similar pattern and accounted for the majority of the natural spawning escapement in Puget Sound (Fig. 12). The recent high spawning escapements and relative stability of the long-term average, is largely the result of harvest management in Puget Sound and terminal area fisheries. During the period from 1965 to 1987 the size of the run returning to Puget Sound increased steadily, and hatchery production accounted for a relatively constant proportion of the run. Since 1987, the run size has declined, but harvest has been scaled back to maintain a relatively constant spawning escapement. The 5-year geometric mean of natural spawning escapement to the US portion of this ESU was 163,000, with a pre-harvest abundance of 445,000. Natural management areas accounted for natural escapement of 106,000 and ocean run size of 237,000. No data to quantify the natural escapement and production in the Canadian portion of this ESU are available.

In response to NMFS concerns about high harvest rates on natural populations, WDFW and NWIFC (1996) provided evidence indicating that harvest rates on populations in natural production were lower than those in hatchery productions area, and were appropriate for and responsive to the productivity of those populations. They also argued that in natural management areas that have hatcheries, hatchery fish constituted a minor portion of the total run size and less than 2% of natural spawners, and the vast majority of hatchery strays were restricted to streams close to the hatchery.

Population Trends and Production

1) Central California coast ESU

Since the status review, we have received no new information for this ESU from which trends or productivity can be estimated.

2) Southern Oregon/Northern California coasts ESU

New information received since the status review for the Oregon portion of this ESU includes updated abundance estimates (cited in the Population Abundance section above), harvest rate indices for coho salmon produced at Cole Rivers Hatchery on the upper Rogue River (discussed under ESU 3 below), and preliminary results of two population sustainability models (discussed under ESU 3 below).

Using terminal run size estimated at Huntley Park as a proxy for escapement and harvest rate index estimates (methods discussed under ESU 3 below) based on coded-wire tag (CWT) recoveries for Cole Rivers Hatchery fish, the BRT estimated both long-term (full available data series) and short-term (most recent 10 years) percent annual change in natural spawning escapement, ocean run size (calculated as escapement divided by 1 - harvest rate), and recruits per spawner (calculated as ocean run size divided by spawners 3 years earlier). Trend estimation methods were discussed in the status review. In estimating ocean run size, terminal sport harvest, which is commonly assumed to have been about 10% for coho salmon until the late 1980s, with recent reductions down to less than 1%, was not adjusted for. In addition, no stock-specific estimates of sport harvest rates were available, and excluding this information compensates somewhat for the bias in the CWT ocean exploitation indices. At present, only incomplete CWT returns for the 1995 return year are available, but preliminary data indicate that harvest rate was extremely low; the assumed 1995 harvest rate was assumed to be equal to the 0.2% rate estimated for 1994. The BRT did not attempt to adjust trends for the contribution of stray hatchery fish; sufficient data for such an adjustment are not available for these populations.

Trends in naturally produced coho salmon escapement (as indexed by terminal run size at Huntley Park), ocean run size, and recruits-per-spawner are illustrated in Figure 13, and summarized in Appendix Table 2. For both long- and short-term trends,. escapement estimates increase, while recruitment and recruits-per-spawner estimates decrease. All three data series exhibit wide fluctuations, so none of the estimated trends are significantly different from zero. The dominance of hatchery fish in the terminal run combined with evidence that hatchery fish are straying in the upper basin (see Population Abundance above) suggests that these trend estimates may include some production from stray hatchery fish, thus overestimating the productivity of the natural population.

Preliminary model results from Chilcote (1996) suggest that this population has a high extinction probability at very low ocean survival, but he notes that ocean survival estimates for the Cole Rivers Hatchery stock indicate that this population has experienced better ocean conditions (3% to 6% survival) than those north of Cape Blanco (1% to 3% survival).

3) Oregon Coast ESU

For the Oregon Coast ESU, in addition to updated information on abundance trends cited above, we have also received updated spawner indices (peak counts per mile and total adults per mile) for ODFW's standard survey segments (S. Jacobs, ODFW, Pers. comm., May 8, 1996), and indices of ocean exploitation for several coho salmon stocks, computed from ocean recoveries of CWT groups released on station from ODFW hatchery programs (Lewis 1996). The spawner survey index data were discussed in the status review. Regarding harvest rates, in the status review the BRT used the Oregon Production Index (OPI) harvest index, which is computed from catch and escapement data for all stocks in the OPI area (extreme southwest Washington through California). The CWT-based indices offer two potential advantages over the OPI index. First, they are direct estimates of exploitation rate with clear statistical properties, while the OPI index is an indirect calculation that depends on assumptions regarding migration patterns and is heavily influenced by the abundance and harvest of Columbia River hatchery stocks. Second, the CWT-based indices allow examination of geographic differences in harvest rates, which in turn allows finer geographic resolution in estimating recruitment and productivity of stocks. There are also disadvantages to using CWT-based indices. First, they are a biased estimate of true exploitation rate because of incomplete tag recoveries in freshwater, which leads to overestimating ocean harvest by an unknown factor. Second, the CWT indices represent only landed catch, and are not adjusted for non-landed catch. This introduces a bias the other direction (underestimating ocean harvest), and this bias would be greater in recent years when coho salmon harvest restrictions have increased the ratio of non-landed to landed harvest mortality. Third, CWT data are only available since the late 1970s or early 1980s, depending on the stock, while the OPI index is available back into the 1960s. Fourth, individual stocks sometimes have small sample sizes, which leads to wide fluctuations in estimated exploitation rates at an individual stock scale.

Despite these disadvantages, the BRT chose to accept ODFW's recommendation to use CWT-based indices (ODFW 1994, 1995a). To alleviate the fourth problem to some degree, the BRT averaged indices over broader geographic areas corresponding to Oregon's coho salmon Gene Conservation Groups (GCGs). Lewis (1996) provided a set of ocean exploitation indices for CWT releases from individual hatcheries based on the ratio of ocean recoveries/total recoveries; indices for all hatcheries within a given GCG were averaged. This provided four index series for the four Oregon coast coho salmon GCGs, three in this ESU and one in the Southern Oregon/Northern California ESU. Figure 14 compares these four indices to the OPI index. In general, the five indices exhibit similar patterns of change in exploitation rate. The three northern indices suggest higher exploitation rates than the OPI index, while the South Coast GCG (south of Cape Blanco) index is generally lower than the OPI index.

Using spawning escapement indices (peak counts per mile in standard spawner surveys) and harvest rate index estimates, the BRT estimated both long-term (full available data series) and short-term (most recent 10 years) percent annual change in natural spawning escapement, ocean run size (calculated as escapement divided by 1 - harvest rate), and recruits per spawner (calculated as ocean run size divided by spawners three years earlier). Trend estimation methods were discussed in the status review. In estimating ocean run size, the BRT did not adjust for terminal sport harvest, which is commonly assumed to have been about 10% for coho salmon until the late 1980s, with recent reductions down to less than 1%. The BRT had no stock-specific estimates of sport harvest rates, and excluding them compensates somewhat for the bias in the CWT ocean exploitation indices. The BRT also did not attempt to adjust trends for the contribution of stray hatchery fish; sufficient data for such an adjustment are not available for these populations.

Trend estimates are summarized in Appendix Table 2 for populations in major coastal basins and for aggregate GCGs. Data for the three GCGs are illustrated in Figures 15, 16, and 17. For all three measures (escapement, run size, and recruits-per-spawner), long term trend estimates are negative in all three GCGs. Recent escapement trend estimates are positive for the Umpqua and Mid/South Coast GCGs, but negative in the North/Mid Coast GCG. Recent trend estimates for recruitment and recruits-per-spawner are negative in all three GCGs, and exceed 12% annual decline in the two northern GCGs. While the SRS population estimate data series (used to estimate total abundance above) is not long enough to reliably estimate population trends, the 6 years of data do show an increase in escapement (Fig. 18) and decrease in recruitment (Fig. 19) in all three GCGs.

As part of the OCSRI process, ODFW staff have developed two models of coastal Oregon coho salmon for the purpose of evaluating sustainability and extinction risk (Chilcote 1996, Nickelson and Lawson 1996). Only preliminary results of these models are available at this time. Both models indicate that the probability of populations sustaining themselves is largely a function of ocean survival (indexed by smolt-to-adult survival of hatchery stocks) and harvest rate, and that many populations will not sustain themselves over 10 generations (30 years) under very low ocean survival (at or below average survival observed in the last 5 years). Chilcote concluded that "[o]cean survivals that are less than 2% for a period greater than 6 years apparently pose considerable risk to these populations." Nickelson and Lawson did not provide actual estimates of extinction risk, but instead examined the behavior of populations under a variety of conditions. One important feature of the Nickelson/Lawson model is geographic variation in freshwater habitat quality, and the model suggests that under extended low survival conditions, coho salmon will be restricted to only the best freshwater habitats. Because coho salmon in higher quality freshwater habitat have a higher probability of sustaining themselves through poor conditions, this leads to higher probabilities of population persistence than would be predicted by a model that assumes uniform habitat within basins.

4) Lower Columbia River

Trends in spawning escapement, ocean run size, and stock productivity for the Clackamas and Sandy Rivers are summarized in Appendix Table 2. Frazier and Murtagh (1995) expanded Marmot Dam adult and jack counts for Columbia River harvest to estimate terminal run size. They expanded terminal run size to ocean run size using OPI harvest rates. Recent trends in run size of Sandy River coho salmon are significantly negative. Because of uncertainty over the natural component of production in the Sandy River, interpretation of these trends remains uncertain. The Clackamas River stock has exhibited a decline in recruitment in recent years, and recruits/spawner has been below one for the last 3 years. Population abundance in the Sandy River has rapidly declined since hatchery releases were halted in 1991. Neither of these populations appear to be self-sustaining at this time. Spawning counts in other lower Columbia River tributaries remain at extremely low numbers.

5) Southwest Washington

Trends in spawning escapement, ocean run size, and stock productivity for Grays Harbor stocks are summarized in Appendix Table 2. In Grays Harbor, terminal run size was calculated by the Quinault Indian Nation (NWIFC 1996b). Terminal run size was expanded to ocean run size using calculated ocean harvest rates for CWT Bingham Creek wild smolts (Dave Seiler, WDFW, Pers. comm., April 6, 1996). Recent estimates of trends in run size of Grays Harbor stocks are all negative, though not statistically significant. Because of uncertainty over the natural component of production in Grays Harbor, interpretation of these trends remains uncertain.

6) Olympic Peninsula

Coho salmon from Queets River hatchery have been coded wire tagged, and ocean exploitation rates calculated since 1982 (NWIFC and WDFW 1996). The BRT used Queets River exploitation rates to calculate ocean abundance (recruitment to the fishery or preharvest run size) for rivers on the west coast of the Olympic Peninsula. Natural stocks in Puget Sound and Hood Canal have been tagged with CWTs and ocean and total exploitation rates calculated back as far as 1976. The average of the ocean exploitation rates for the Skykomish River, Deschutes River and Big Beef Creek was similarly used to calculate ocean run size for aggregated streams on the Strait of Juan de Fuca. In neither case was an estimate of ocean exploitation rate available for 1995. The BRT used an estimate of 0.3 as an ocean exploitation rate because it was similar to the values for both areas in 1994 (0.296 for Queets River and 0.287 for Puget Sound). The estimated ocean exploitation rates for Queets River Hatchery coho salmon have declined over the period from 1982 to the present (Fig. 20). As a result, trends in ocean run size and calculated recruits-per-spawner are steeper than terminal run size or spawning escapement (Fig. 21).

Stock productivity, defined as recruits-per-spawner, was estimated by dividing the back-calculated ocean run size by natural spawning escapement, and trends in escapement, ocean run size, and productivity are summarized in Appendix Table 2. Trends in these measures prior to the 1994 return were negative but not statistically significant. However, as a result of the low abundance in 1994, the negative trend in escapement for the Quillayute River summer run has become significant. Negative trends in ocean run size for the Quinault River, Quillayute River summer and fall runs, and the Hoh River runs have all become significant, and negative trends in productivity for the Hoh and Quillayute summer runs have become significant (Fig. 21).

7) Puget Sound - Strait of Georgia

For the Puget Sound portion of this ESU, spawning escapement and Puget Sound run size were calculated from the Run Reconstruction Database (Foy et al. 1995, NWIFC 1996a). Puget Sound run size was then expanded to account for ocean harvest using averaged ocean exploitation rates for South Fork Skykomish River, Deschutes River, and Big Beef Creek wild tagging studies Dave Seiler (WDFW, Pers. comm., 3 Nov. 1995). Exploitation rate estimates were available for only the Skykomish River in 1976 and 1977, and the Deschutes River in 1994, but all three stocks show similar exploitation rates (Fig. 22). Due to similarities between ocean fisheries in 1994 and 1995, a rate of 0.3 was assumed for 1995. The Deschutes River ocean exploitation rate in 1994 was 0.287. Puget Sound ocean exploitation rates have varied, but have not declined over time to the degree that Oregon coast and Olympic Peninsula ocean exploitation rates have. As a result, the differences between trends in escapement and trends in ocean abundance and productivity are a reflection of terminal harvest policies (Appendix Table 2).

SUMMARY AND CONCLUSIONS OF RISK ASSESSMENTS

The following summary and conclusions are based on information presented in Weitkamp et al. (1995), supplemented by information in this report.

1) Central California coast

The following summarizes BRT conclusions for Central California coast coho salmon. A more complete discussion of the conclusions can be found in a memorandum from Michael H. Schiewe to William Stelle Jr., dated October 17, 1996 (NMFS 1996). All coho salmon stocks south of Punta Gorda are depressed relative to past abundance, but there are limited data to assess population numbers or trends. Updated presence/absence data indicated that the proportion of streams with coho salmon present was higher than was previously estimated. The main stocks in this ESU have been heavily influenced by hatcheries, and there are apparently few native coho salmon left in this ESU. The apparent low escapements in these rivers and streams, in conjunction with extensive historical hatchery production, suggest that the natural populations are not self-sustaining. Determination of extinction risks due to artificial propagation of coho salmon are confounded by extremely low natural population levels in this ESU. For example, although only three basins (Scott Cr., Russian and Noyo Rivers) have hatcheries, and release levels are minuscule compared to hatcheries farther north, much of the production from those basins appears to be of hatchery origin. Most basins in this ESU were planted in the 1960s and 1970s with exotic stocks but have not been planted since, and it is unclear whether those releases affected current populations. The status of coho salmon stocks in most small coastal tributaries is not well known, but these populations are thought to be extremely small, often less than 50 or 100 individuals.

After considering this information, a majority of the BRT concluded that this ESU is presently in danger of extinction, while a minority concluded that it is not presently in danger of extinction, but is likely to become so in the foreseeable future.

2) Southern Oregon/Northern California coasts

Estimates of natural population abundance in this ESU continue to be based on very limited information. Favorable indicators include recent increases in the Rogue and Trinity Rivers and presence of natural populations in both large and small basins, which may provide some buffer against extinction of the ESU. However, large hatchery programs in the two major basins (Rogue and Klamath) raise serious concerns about effects on, and sustainability of, natural populations. For example, available information indicates that virtually all of the naturally spawning fish in the Trinity River are first generation hatchery fish. Several hatcheries in the California portion of this ESU have extensively used exotic stocks in the past, in contrast to Cole Rivers hatchery which has only released Rogue River stock into the Rogue. These new data on presence/absence in streams that historically supported coho salmon are even more disturbing than earlier results, indication that a smaller percentage of streams contain coho salmon in this ESU compared to the percentage presence in the ESU to the south. However, it is unclear whether these new data represent actual trends in local extinctions, or are biased by sampling effort.

In summary, the new information did not substantially change the overall assessment of risk to this ESU, and the BRT concluded that the ESU is likely to become endangered in the foreseeable future. Most members felt that the degree of risk faced by this ESU was slightly less than that faced by the Central California Coast ESU.

3) Oregon Coast

Abundance and trends of coho salmon in this ESU have continued to decline since the status review. Recruitment and escapement remain a small fraction of historical abundance. While natural escapement has been on the order of 50,000 fish per year in this ESU, up slightly since the status review, this has been coincident with drastic reductions in harvest. Spawning is distributed over a relatively large number of basins, both large and small. Both recruitment and recruits-per-spawner have been declining rapidly (12% to 20% annual declines over the last 10 years) in two of the three GCGs in this ESU. These declines are steeper and more widespread in this ESU than in any other for which data are available, and productivity has continued to decline since this ESU was reviewed in 1994. Risks that this decline in productivity pose to sustainability of natural populations, in combination with strong sensitivity to unpredictable ocean conditions, was the most serious concern identified by the BRT for this ESU. Preliminary results of the ODFW viability model suggest that most Oregon coastal stocks cannot sustain themselves at ocean survivals that have been observed in the last 5 years, even in the absence of harvest. Consequently, a major question in evaluating extinction risk for this ESU is whether recent ocean and freshwater conditions will continue into the future.

Scale data indicating widespread spawning by hatchery fish was also a major concern to the BRT. Scale analysis to determine hatchery-wild ratios of naturally spawning fish indicate moderate to high levels of hatchery fish spawning naturally in many basins on the Oregon coast, and at least a few hatchery fish were identified in almost every basin examined. Although it is possible that these data do not provide a representative picture of the extent of this problem, they represent the best information available at the present time. In addition to concerns for genetic and ecological interactions with wild fish, these data also suggest that the declines in productivity in many areas may have been even more alarming than current estimates indicate. However, Oregon has made some significant changes in its hatchery practices, such as drastically reducing production levels in some basins, switching to on-station smolt releases, and minimizing fry releases, and proposes additional changes, to address this and other concerns about the impacts of hatchery fish on natural populations.

Another concern discussed by the BRT is the asymmetry in the distribution of natural spawning in this ESU, with a large fraction of the fish occurring in the southern portion and relatively few in northern drainages. Northern populations are also relatively worse off by almost every other measure: steeper declines in abundance and recruits-per-spawner, higher proportion of naturally spawning hatchery fish, and more extensive habitat degradation.

The BRT considered the listing thresholds proposed by ODFW for this ESU (OCSRI Science Team 1996b), which were based on the Nickelson-Lawson model and are much lower than current abundance levels. However, the BRT did not feel that this model is a reliable indicator of extinction risk, for several reasons: 1) it depends heavily on strong compensation at low population levels, but the dynamics of very small populations are poorly understood and unpredictable; 2) it does not incorporate genetic concerns; 3) it is based on freshwater production parameters estimated from a variety of studies, with no means of adjusting parameters to the specific conditions of local basins; 4) it does not incorporate any measure of uncertainty in parameters or model structure. The BRT also did not feel that the methods used to derive listing thresholds from the model were appropriate.

ODFW has proposed reforms in two areas--harvest and hatcheries--that, if carried out, should significantly reduce risks to natural populations. The harvest rate reductions are substantial and should help to ensure that excessive harvest does not limit recovery of populations in the ESU. However, the harvest reductions by themselves are unlikely to lead to recovery unless freshwater and marine productivity increases. ODFW has also proposed significant reductions in hatchery production, as well as shifting to more extensive use of local broodstocks. Some of these hatchery reforms have already been implemented. The majority of the BRT felt that hatchery reforms would cause "some" or a "strong" improvement in the status of the ESU. However, it was recognized that more details are needed on the extent of genetic and ecological interactions of hatchery fish with natural populations before these reforms can be fully evaluated.

With respect to habitat, the BRT had two primary concerns. First, that the habitat capacity for coho salmon within this ESU had significantly decreased from historical levels, and second, that Nickelson's model predicted that during poor ocean survival, only high quality habitat was capable of sustaining coho populations, and subpopulations dependent on medium and low quality habitats would go extinct. Both of these concerns caused the BRT to consider risks from habitat to be relatively high for this ESU.

The BRT concluded that this ESU is not at significant short-term risk of extinction, but most members felt that it is likely to become endangered in the foreseeable future. A minority felt that the ESU is not at risk of endangerment. Some members saw a number of parallels in risk factors between this ESU and the Olympic Peninsula and to some extent the Puget Sound/Strait of Georgia ESU, and felt that these ESUs should be in the same risk category; others saw significantly higher risk in the Oregon Coast ESU.

4) Lower Columbia River

From a population dynamics perspective, the status of coho salmon in this ESU has worsened since the status review was completed in 1994. Abundance estimates for both the Clackamas and Sandy Rivers have steeply declined in recent years, and recruitment of the Clackamas stock has been below replacement. As noted above, the BRT could not determine with any certainty whether the Clackamas and/or Sandy River populations are still part of the historic ESU. However, if either or both populations are part of the ESU, the BRT concluded that the ESU is in danger of extinction. The best available information suggests that all or almost all native populations in the historic ESU have been extirpated or changed dramatically by a combination of human factors (harvest, hatcheries, habitat blockage, and degradation). The Clackamas River population is small, but until recently, escapement has been relatively stable. However, this has been accomplished by substantially reducing harvest rates, and recruits-per-spawner data indicate a precipitous decline in productivity of this population. Recent data for natural fish in the Sandy River are even bleaker, and the possible inclusion of this population in the ESU would in no way alleviate concerns for its overall risk.

5) Southwest Washington

In the status review, little information was available about the origin or status of naturally spawning coho salmon in this area. Information developed since that time indicates that natural production is largely restricted to the upper Chehalis River Basin, with the remaining areas in the ESU dominated by hatchery production. In addition, a single year of data suggests that natural production of several thousand fish may occur in the North River in Willapa Bay, but the origins of that population are unclear.

The strongest positive factor for this ESU is natural escapement in excess of 20,000 fish per year in the Chehalis River Basin. The second largest drainage in the state of Washington, the Chehalis River Basin contains large expanses of low-gradient habitat that historically was ideally suited for coho salmon production. Considerable habitat degradation has occurred, but remaining habitat is still in generally better condition than degraded habitats in most other coastal areas. Although spawning and rearing habitat has been degraded or is limiting, it is possible that substantial over-winter habitat still exists, and this is often the limiting habitat factor in other basins.

Most other indicators for this ESU are moderately to strongly negative. The most serious concern for the BRT is that natural production is largely restricted to a small portion of the ESU. [On the other hand, it is possible that the Chehalis River has always dominated coho salmon production in this area.] In addition, SASSI considers all stocks in this ESU to be of "composite" production, that is, sustained by both wild and artificial production. The BRT had substantial concerns for genetic effects of hatchery fish on natural populations, both with respect to loss of fitness and loss of diversity among populations. For example, the historical separation between early and late runs in Grays Harbor no longer exists--a fact that can probably be attributed to a combination of harvest and hatchery effects. Widespread use of unmarked fry outplants, even in natural production areas, increases uncertainty about the sustainability of natural populations. For example, if fry outplants have contributed substantially to natural escapement in recent years, the decline in recruits-per-spawner for the Chehalis River would be even more dramatic than current data indicate (a decline of >12% per year).

Another major concern expressed by the BRT was the interaction of disease, pollution (from pulp mills), and habitat degradation from logging to severely reduce productivity in the Chehalis River basin and estuary.

The mixed signals from the various stock status indicators were reflected in a wide range of views expressed by the BRT regarding the degree of extinction risk faced by this ESU. A majority felt that this ESU was likely to become endangered (with one member concluding that it already was at risk of extinction), while slightly less than half felt that it was not. One member in the latter group questioned whether the ESU still exists.

6) Olympic Peninsula

This ESU was not proposed for listing in 1995, nor was it identified as a candidate species. Therefore, the BRT did not formally solicit information or comments on, nor conduct a formal risk assessment for, Olympic Peninsula coho salmon. However, for several reasons it was important to consider information for coho salmon from this area in this study: 1) Each of the other ESUs was being reviewed, and including information from the Olympic Peninsula was the best way to ensure that the evaluations were comprehensive and consistent across geographic areas; 2) Some peer review and public comments compared the status of populations from the Olympic Peninsula and the Oregon coast and questioned whether the Olympic Peninsula populations were at less risk; 3) There was not time during the initial status review to perform as detailed analyses as we would have liked of trend, harvest, and abundance data for this ESU; and 4) The BRT now has data for at least 2 additional years beyond those considered in the previous status review, and these recent years include some of the lowest run sizes for Olympic Peninsula coho salmon on record. The BRT thus considered whether information for Olympic Peninsula coho salmon warrants reopening a formal status review for this ESU.

The BRT identified several positive attributes for this ESU. For example, most of the larger rivers had substantial natural production, some high-quality habitat is protected within the Olympic National Park, and current management appears to be responsive to predicted run size. Accordingly, the BRT did not identify any individual risk factor as a major concern for this ESU; however, there are a number of moderate concerns. This ESU does not have any individual populations that can be considered large (all except the hatchery-enhanced Quillayute fall run have recent geometric mean escapements less than 5,000 fish), and natural escapement is less than that for the Puget Sound, Southwest Washington, or Oregon Coast ESUs. There were also concerns associated with small population size for the Strait of Juan de Fuca populations within this ESU. Recent low spawning escapements in 1994 and 1995, which have occurred during a period of relatively low ocean exploitation rates, have reduced the recent abundance and increased the magnitude of negative trends in abundance and productivity of populations in this ESU. All stocks for which we have data have long-term declines in recruits-per-spawner, with 4 of 6 stocks showing declines of 5-10% per year. Coastal coho salmon, including those from the Olympic Peninsula, appear to be more sensitive to fluctuations in ocean productivity than those in Puget Sound, and the relatively low abundance of most populations in this ESU may place them at greater risk from environmental fluctuations. Hatchery propagation is less extensive than in some other ESUs but is a concern in some basins. Although little is known about the impact of hatchery fish on natural production in this ESU, relatively high levels of artificial production in some basins (Quinault, Queets, Quillayute, Sooes) provide an opportunity for impacts to occur. On a slightly optimistic note, some BRT members noted that logging is expected to decrease in the future because most exploitable timber has already been harvested. This may provide some benefits in terms of improved habitat conditions, although positive effects are not likely to be seen for many years.

The majority of the BRT members felt that the above information warrants reopening the status review for this ESU. It should be possible to develop more extensive information about risk factors in a number of areas, such as the contribution to or impact of hatchery fish on natural populations, harvest management objectives and practices, and the relative condition of habitats within the ESU. A minority of the BRT felt that reopening the review was not justified based on current information.

7) Puget Sound - Strait of Georgia

Little has changed in the status of this ESU since the original status review was conducted. However, many of the questions the BRT raised about the status of natural populations have been answered to varying degrees. The majority of natural production and spawning escapement in Puget Sound occurs in basins managed for natural escapement and production (Skagit, Stillaguamish, Snohomish Rivers, and South and Central Hood Canal). Although WDFW and NWIFC have determined the stock origin in most of these areas to be mixed and production results from both natural and hatchery sources, hatchery influence is less than in other areas and the populations appear to be stable. Harvest rates on these natural stocks are generally lower than on stocks in areas managed for hatchery production due to the absence or restriction of directed terminal area fisheries.

Size of adults in this ESU increased in the 1994 and 1995 return years, although they are still generally smaller than they were 5 years ago. Limited data on size of natural spawners indicate downwards trends, although they do not appear to be declining as steeply as some hatchery stocks.

Artificial propagation of coho salmon in this ESU is widespread and involves the release of tens of millions of fry and smolts annually. This total includes several million smolts released from net-pens, which have been documented to stray to streams in the general vicinity of the pens. However, natural production areas have generally received no or very restricted releases of hatchery fish in recent years, consistent with WDFW's management policies.

Overall abundance of coho salmon, including both natural and artificial production, is much higher in this ESU than in any of the other coho salmon ESUs. In the U.S. portion alone, estimated run size has been approximately a half million fish in recent years, with geometric mean escapement over 150,000. Three drainages that are dominated by natural production have had recent spawning escapements in excess of 10,000 fish, led by the Snohomish River with a geometric mean of over 75,000. This is also the only ESU to have more populations with increasing than decreasing long-term trends in escapement. Although the majority of trends in recruits-per-spawner are negative, the declines have been less severe than in other ESUs.

On the other hand, there are several reasons for concern about the health of natural populations of coho salmon in this ESU. First, the BRT lacks detailed information for coho salmon in the Canadian portion of this ESU, but available data indicate that natural populations in British Columbia have undergone substantial declines in recent years. Second, artificial propagation of coho salmon is conducted on an immense scale in both the Canadian and U.S. portions of this ESU. Large geographic areas of Puget Sound (e.g., the Nooksack River and all the southern drainages) are managed for hatchery production, and little natural production is expected (or encouraged) from streams in these areas. Finally, the decline in adult size of coho salmon has been dramatically sharper in Puget Sound than in other areas of the Pacific Northwest.

After weighing these various factors, the majority of the BRT concluded that this ESU is neither at risk of extinction nor likely to become so in the foreseeable future. A minority felt that the ESU is likely to become endangered. A key factor was the presence of several relatively large populations in natural production areas in north Puget Sound, which suggests that the ESU as a whole is not at significant extinction risk. There was also less concern for declining trends or small population risks (except in areas given over to hatchery production) than in other ESUs. The most important concern identified by the BRT was that the demonstrably healthy, naturally sustaining populations in this ESU are few and geographically clustered in a relatively small area of northern Puget Sound. Some felt that this ESU could be considered to be at risk in a significant portion of its range. The BRT was also concerned about declines in adult size and its likely effects on productivity and resilience of natural populations, and for genetic and ecological effects of hatchery production.

The BRT agreed that several risk factors for this ESU should be monitored closely in the future. Better information is needed on the extent of natural spawning by hatchery fish and their effects on natural populations. In response to dramatically reduced run size in recent years, fishery managers have shown a willingness to take strong action to reduce harvest rates. If and when coho salmon stocks coastwide rebuild in the future, it will be important to monitor harvest rates to ensure that they are compatible with sustainable natural production. The lack of effective U.S. control over harvest off the west coast of Vancouver Island is a continuing conservation concern. Habitat degradation remains an important concern for this ESU, and continued urbanization of the Puget Sound/Strait of Georgia areas suggests that habitat limitations will place increasing pressure on natural populations in the future.

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Table 1. New data received and analyses conducted since the West coast coho salmon status review (Weitkamp et al. 1995).

Central California coast ESU

Updated hatchery release information
Considerably more information about Cooperative hatchery programs, stock histories, and practices
Updated coho presence/absence data
Updated weir counts (returns to hatchery racks)

Northern California/Southern Oregon coasts ESU

Updated hatchery release information
Considerably more information about Coop hatchery programs, stock histories, and practices
Updated coho presence/absence data
Updated weir/dam counts (returns to hatchery racks, Willow Creek weir, Gold Ray Dam)
Estimated proportion of hatchery spawners in the Trinity River
New and updated information on southern Oregon coho distribution and abundance

Oregon Coast ESU

Updated hatchery release information
Considerably more information about ODFW and private hatchery and stock histories, practices, and proposed plans
Updated escapement data
Updated weir/dam counts (Winchester dam)
New estimated harvest rates
New models of population demographics
New estimates of proportion of hatchery fish spawning naturally
New proposed harvest rates
New proposed conservation measures
New information about habitat quality

Lower Columbia River/Southwest Washington coast ESU

Updated hatchery release information
Considerably more information about ODFW and WDFW hatchery and stock histories, practices, and proposed releases
Updated escapement and juvenile survey data
Updated weir/dam counts (NF Clackamas Dam, Marmot [Sandy R.] Dam)
New information on the status of Sandy and Clackamas River coho
New estimates of proportion of hatchery fish spawning naturally (SW Washington)
New escapement data for North River (SW Washington)
New genetic data for SW Washington populations

Table 1. Continued.

Lower Columbia River/Southwest Washington coast ESU (continued)
New information on late-run coho in the Satsop, Wishkah, and Wynoochee Rivers (SW Wash.) (USFWS).
New information on wild and hatchery run timing (Chehalis River)
New estimates of coho productivity and limiting factors
New information on former and current studies estimating smolt productivity
Olympic Peninsula ESU
Updated hatchery release information
Considerably more information about WDFW and tribal hatchery and stock histories, practices, and proposed releases
Updated escapement and juvenile survey data
New estimates of coho productivity and limiting factors (Queets, Quillayute River Basins)
New information on former and current studies estimating smolt productivity
New information on habitat conditions
New estimates of harvest rates
Puget Sound/Strait of Georgia ESU
Updated hatchery release information
Considerably more information about WDFW and tribal hatchery and stock histories, practices, and proposed releases
Updated escapement and juvenile survey data
Updated weir/dam counts
New estimates of proportion of hatchery fish spawning naturally (several basins)
New estimates of coho productivity and limiting factors (numerous basins)
New information on former and current studies estimating smolt productivity
Updated and new information on adult size and fecundity
New analyses of harvest rates on wild and hatchery stocks and adequacy of existing management
New information on general Puget Sound management strategies
New information on habitat conditions

Table 2. Samples of coho salmon used in the new allozyme analysis of lower Columbia River and southwest Washington populations. Samples are referred to in figures by the sample numbers shown here. N is the number of fish in each sample. Samples which were analyzed after the 1994 Status Review are indicated by bold type. All samples are from juvenile fish except samples 31 and 40, which are from adult coho salmon.

Sample Number	Area	Source	Brood Year	N
Columbia River				
1	Lewis and Clark	Lewis and Clark River	1992	30
2	Grays	Grays River Hatchery	1989	40
3	Grays	Grays River Hatchery	1989	40
4	Grays	Grays River Hatchery	1982	100
5	Big	Big Creek Hatchery	1989	80
6	Clatskanie	Carcus Creek	1989	50
7	Cowlitz	Cowlitz River Hatchery Late	1990	100
8	Cowlitz	Cowlitz River Hatchery Early	1989	80
9	Cowlitz	Cowlitz River Hatchery Late	1989	80
10	Scappoose	Siercks, Raymond, and Milton Creeks	1989	44
11	Lewis	Lewis River Hatchery Late	1989	80
12	Lewis	Lewis River Hatchery Early	1989	80
13	Clackamas	North Fork Clackamas River	1990	90
14	Clackamas	Clackamas and North Fork Clackamas Rivers	1989	60
15	**Clackamas**	**North Fork Clackamas River**	**1994**	**50**
16	Eagle	Eagle Creek Hatchery	1990	100
17	Eagle	Eagle Creek Hatchery	1989	80
18	Sandy	Sandy River Hatchery	1989	80
19	Sandy	Still Creek	1989	62
20	Sandy	Sandy River Hatchery	1990	100
21	**Sandy**	**Sandy River at Marmot Dam**	**1991**	**29**
22	**Sandy**	**Sandy River at Marmot Dam**	**1994**	**33**
23	Hardy	Hardy Creek	1989	50
24	Bonneville	Bonneville Hatchery	1989	80
25	Willard	Willard Hatchery	1989	80
S.W. Washington Coast				
26	**Bear**	**Bear River, Spyder Creek**	**1994**	**37**
27	Naselle	Naselle River Hatchery	1990	100
28	Nemah	Nemah River Hatchery	1990	100

Table 2. Continued.

Sample Number	Area	Source	Brood Year	N
S.W. Washington Coast, continued				
29	Willapa	Willapa River Hatchery	1990	100
30	North	North River, Pioneer Creek	1994	36
31	Chehalis	Simpson River Hatchery	1988	40
32	Chehalis	Simpson River Hatchery	1989	40
33	Chehalis	Simpson River Hatchery	1993	100
34	Chehalis	Satsop River, Bingham Creek	1982	100
35	Chehalis	Satsop River, Bingham Creek	1993	98
36	Chehalis	Upper Chehalis River at Rochester	1993	91
37	Chehalis	Upper Chehalis River, Hope Creek	1993	80
38	Chehalis	Upper Chehalis River, Hope Creek	1994	55
39	Chehalis	Upper Chehalis River, Stillman Creek	1994	71
40	Chehalis	Upper Chehalis River, Oakville Fishery	1992	79
41	Humptulips	Humptulips River Hatchery	1988	40

Table 3. Estimated percent hatchery contributing to natural spawning for various coho salmon populations based on scale analysis, CWT recoveries, or fin clips.

Basin	Subbasin	Years sampled	Method*	Total N	Avg. % Hatchery	Source
Central California ESU						
Scott Cr.		1994/95	RV, LV, ad	82	72	1
Southern Oregon/northern California coasts ESU						
Trinity above Willow Cr. weir		1991-95	CWT	many	91-100	2
Rogue	L. Mainstem	1990-95	scale	0		3
Oregon Coast						
Necanicum		1989-95	scale	34	42	3
Ecola/Elk Cr.		1991-95	scale	8	44	3
Arch Cape Cr		1991	scale	4	50	3
Nehalem	Mainstem	1989-95	scale	169	35	3
	N. Nehalem	1989-95	scale	466	89	3
Tillamook	Kilchis	1989-95	scale	20	59	3
	Miami	1991-95	scale	5	56	3
	Tillamook	1991-95	scale	15	69	3
	Trask	1989-95	scale	333	81	3
	Wilson	1989-95	scale	27	38	3
Sand Lake		1992-95	scale	3	33	3
Nestucca		1989-95	scale	37	27	3
Neskowin		1992-95	scale	1	100	3
Salmon		1985	scale	110	72	4
Salmon		1989-95	scale	656	79	3
Devils Lake		1991-95	scale	36	12	3
Siletz	Mainstem	1985	scale	66	15	4
Siletz	Mainstem	1989-95	scale	160	61	3
	Rock Cr	1989-95	scale	124	79	3
	Schooner Cr. Trap	1990	scale	25	96	3
Yaquina	Tidewater	1980-85	scale	779	21	4
	L. Big Elk and Yaquina	1980-85	scale	429	82	4
	Upper Yaquina	1980-85	scale	286	72	4
	Upper Big Elk	1980-85	scale	420	54	4
	Total	1980-85	scale	1713	70	4
Yaquina		1989-95	scale	226	73	3
Beaver Cr		1985	scale	56	50	4
Beaver Cr		1989-95	scale	18	0	3
Alsea	Mainstem	1990-95	scale	31	47	3
	Drift Cr	1985	scale	144	44	3
	Drift Cr	1989-95	scale	110	8	3
	Five Rivers	1985	scale	60	5	3
	Five Rivers	1989-95	scale	145	17	3
Yachats		1985	scale	4	75	4
Yachats		1989-95	scale	19	43	3

Table 3. Continued.

Basin	Subbasin	Years sampled	Method*	Total N	Avg. % Hatchery	Source
Oregon Coast ESU, cont.						
Siuslaw		1985	scale	64	0	4
Siuslaw	Mainstem	1989-95	scale	91	17	3
	N. Siuslaw	1990-95	scale	13	4	3
	Lake Cr	1989-95	scale	263	40	3
Siltcoos		1989-95	scale	331	8	3
Tahkenitch		1989-95	scale	569	5	3
Umpqua	Mainstem	1989-95	scale	99	16	3
	Smith	1989-95	scale	335	4	3
	Elk Cr	1992-95	scale	49	0	3
	S. Umpqua	1989-95	scale	129	35	3
Tenmile		1989-95	scale	169	0	3
Coos	Mainstem	1989-95	scale	216	23	3
	Tidewater	1983-85	scale	112	37	4
	Millicoma	1983-85	scale	200	17	4
	Millicoma	1989-95	scale	185	6	3
	S. Coos	1983-85	scale	268	19	4
	S. Coos	1989-95	scale	335	11	3
Coquille	Mainstem	1990-91	scale	29	54	3
	N. Coquille	1989-95	scale	202	9	3
	E. Coquille	1989-95	scale	54	15	3
	M. Coquille	1990-95	scale	70	7	3
	S. Coquille	1990-95	scale	26	20	3
New		1990-95	scale	41	14	3
Lower Columbia River/southwest Washington coast ESU						
Humptulips	Below hatchery	1995/96	scale & CWT	48	29	5
	Hatchery tribs	1995/96	scale & CWT	68	84	5
	Above hatchery	1995/96	scale & CWT	172	93	5
Humptulips total		1995/96	scale & CWT	288	80	5
Hoquiam		1995/96	scale & CWT	308	4	5
Chehalis basin	Wishkah	1995/96	scale & CWT	58	16	5
	Wynoochee	1995/96	scale & CWT	13	23	5
	Satsop near hatchery	1995/96	scale & CWT	30	87	5
	Satsop below hatchery	1995/96	scale & CWT	24	0	5
	Chehalis below Satsop	1995/96	scale & CWT	2	100	5
	Chehalis above Satsop	1995/96	scale & CWT	100	3	5
	Upper Chehalis	1995/96	scale & CWT	72	10	5
Chehalis basin total		1995/96	scale & CWT	299	17	5
	Westport area	1995/96	scale & CWT	213	3	5
Chehalis	Oakville fishery	1983-94	CWT, ad	19,332	<1	6

Table 3. Continued.

Basin	Subbasin	Years sampled	Method*	Total N	Avg. % Hatchery	Source
Puget Sound/Strait of Georgia ESU						
Port Gamble Tribs		1995/96	scale & CWT	63	93	5
Big Beef Cr		1995/96	scale & CWT	1,963	38	5
Dewatto		1995/96	scale & CWT	668	1	5
Skokomish	NF	1995/96	scale & CWT	22	5	5
Dosewallips		1995/96	scale & CWT	23	96	5
Dabob Bay	Little Quilcene	1995/96	scale & CWT	57	90	5
	Tarboo/Thorndyke Cr	1995/96	scale & CWT	17	76	5
Chimicum Cr		1995/96	scale & CWT	181	50	5
Deschutes		1980-94	CWT	64,537	2	6
		1992-94	scale	3,947	8	6
Skagit	Baker R	1994	CWT	259	1	6
Skagit	Throughout basin	1985-90	CWT	21,432	1.0	7
Snohomish	Below Sunset Falls	1984	CWT	500	0	6
	Throughout basin	1986	CWT	5,069	0	6
Lower Fraser R	Various streams	1988	CWT & ad	3350	59	8
Quinsam		1980-83	CWT	--	<1	9
Quinsam		1985-88	CWT	--	<1	10
Black Cr		1985-88	CWT	--	<1	10
Putledge		1978-83	CWT	--	<1	9
Putledge		1985-88	CWT	--	6	10
Trent		1985-88	CWT	--	31	10
Roswall Cr		1986-88	CWT	--	<1	10
Big Qualicum		1978-83	CWT	--	<1	9
Big Qualicum		1985-88	CWT	--	<1	10
Little Qualicum		1985-88	CWT	--	2	10
French Cr		1985-88	CWT	--	<1	10
Millstone R		1986-88	CWT	--	<1	10

* Methods are scale analysis, recovery of coded wire tags (CWT) or fin clips--RV=right ventral, LV=left ventral, ad=adipose.

Sources:
1--Monterey Bay Salmon and Trout Project 1995
2--U.S. Fish and Wildlife Service 1996
3--Borgerson 1991, 1992, Jacobs 1996
4--Jacobs 1988
5--Ruggerone 1996
6--Seiler 1996a
7--Hayman 1994
8--Atagi and Wilson 1993
9--Quinn and Tolson 1986
10--Labelle 1992

Table 4. Comparison of data compiled by NMFS and ODFW on origin (hatchery or natural) of naturally spawning coho salmon based on scale analysis. These data compilations were used to assess the frequency and distribution of hatchery fish spawning naturally along the Oregon coast. NMFS estimate compiled from data in Borgerson 1991, 1992; Jacobs 1996. ODFW estimate provided by Nickelson and Jacobs 1996.

		NMFS Estimate (1989-95)			ODFW Estimate (1992-95)		
			Mean % H[1]				
Basin	Subbasin	N	unweigh.	weighted	N	% H	Comments
Necanicum		34	42	38	17	53	
Ecola/Elk Cr.		8	44	25			
Arch Cape Cr		4	50	50			
Nehalem	Mainstem	169	35	37	32	47	12 samples from Fishhawk Lake, difficult to ID
	N. Nehalem	466	89	89	115	92	Site of Nehalem Hatchery
	Rock Cr				5	0	
Tillamook Bay	Kilchis	20	59	65	3	33	Higher percentage wild than NMFS estimate
	Miami	5	56	60			
	Tillamook	15	69	53	8	50	Lower percentage wild than NMFS estimate
	Trask[2]	333	81	89	60	85	Site of Trask Hatchery
	Wilson[3]	27	38	22	6	17	Higher percentage wild than NMFS estimate
Sand Lake		3	33	33	3	33	
Nestucca		37	27	14	22	9	
Neskowin		1	100	100	1	100	
Salmon		656	79	88	44	93	Site of Salmon Hatchery
Devils Lake		36	12	14	6	17	
Siletz	Mainstem	160	61	54			
	Rock Cr	124	79	73			
	Schooner Cr. Trap	25	96	96			
	All				30	43	Higher percentage wild than NMFS estimate
Yaquina[4]		226	21	17	13	8	Higher percentage wild than NMFS estimate
Beaver Cr[5]		18	0	0	6	0	
Alsea	Mainstem	31	47	65	26	69	Site of Fall Cr. Hatchery
	Drift Cr	110	8	7	21	10	
	Five Rivers	145	17	6	27	0	Higher percentage wild than NMFS estimate
Yachats		19	43	32	5	20	
Sutton Lake					6	17	Lake in system, identification problems?

Table 4. Continued.

		NMFS Estimate (1989-95)			ODFW Estimate (1992-95)		
			Mean % H[1]				
Basin	Subbasin	N	unweigh.	weighted	N	% H	Comments
Siuslaw	Mainstem	91	17	14	10	40	Lower percentage wild than NMFS estimate
	N. Siuslaw	13	4	8	4	0	Higher percentage wild than NMFS estimate
	Lake Cr	263	40	56	50	40	17 hatchery-classified samples from vicinity of hatchery smolt releases.
	Wolf Cr				2	0	
Siltcoos		331	8	3			
Tahkenitch		569	5	1			
Umpqua	Mainstem	99	16	8	13	8	
	Smith	335	4	2	154	1	
	Elk Cr	49	0	0	16	0	
	S. Umpqua	129	35	35	53	23	Higher percentage wild than NMFS estimate
Tenmile		169	0	1			
Coos	Mainstem	216	23	10	22	9	
	Millicoma	185	6	5	134	3	
	S. Coos	335	11	5	298	3	
Coquille	Mainstem	29	54	14			
	N. Coquille	202	9	3	49	2	
	E. Coquille	54	15	11	11	9	
	M. Coquille	70	7	6	42	0	Higher percentage wild than NMFS estimate
	S. Coquille	26	20	15	9	22	Lower percentage wild than NMFS estimate
New		41	14	22			
Rogue	L. Mainstem	0					

[1] Unweighted mean % hatchery composition are averaged by year, while weighted means are weighted by the number of scales examined each year.
[2] Data only from SF Trask in 1989, 1990 (NMFS estimates only).
[3] Includes mainstem, Little North Fork and Devils Lake Fork Wilson River in 1989; only Devil's Lake Fork in 1990 (NMFS estimates only).
[4] Includes mainstem, Elk Cr. & Little Elk Cr in 1989, mainstem & Big Elk Cr in 1990 &1991 (NMFS estimates only).
[5] Data only from NF Beaver Cr in 1989, 1991 (NMFS estimates only).

Table 5. Summary statistics of historical and current presence-absence data for coho salmon from the California portion of the Southern Oregon/Northern California ESU. Historical data were taken from the literature and current data determined from surveys conducted by NMFS Southwest Fisheries Science Center (P. Adams, Pers. comm., Aug. 27, 1996). Presence data from Brown et al. (1994) are also included for comparison.

Area	Streams historically inhabited by coho salmon	Streams recently surveyed	Number of streams[1] with coho salmon present	Percent of streams with coho salmon present	
				New data	Brown et al. (1994)
Del Norte County	130	46	21	46	55
Humboldt County	234	130	71	55	69
Total	364	176	92	52	63

[1] Refers to those streams recently surveyed.

Table 6. Estimated spawning population size of coastal coho in geographic areas of the Oregon coast north of Cape Blanco in 1990-1995, based on stratified random sampling spawner surveys (Jacobs and Cooney 1991, 1992, 1993). New data from Nickelson (1996), S. Jacobs (ODFW, Pers. comm., 2 Dec 1996).

Group	1990	1991	1992	1993	1994	1995
Mid- to North Coast GCG						
Necanicum-Nehalem	1,743	5,315	1,453	3,207	2,777	1,775
Tillamook-Nestucca	455	3,967	969	1,303	1,315	2,193
Salmon-Alsea	2,419	2,964	11,552	2,884	6,413	7,181
Yachats-Siuslaw	3,173	3,791	3,820	4,895	3,300	6,437
Umpqua GCG						
Umpqua	3,737	3,600	2,153	9,311	4,485	11,020
Mid- to South Coast GCG						
Lakes	4,414	7,283	1,585	10,145	5,841	11,216
Coos-Coquille	4,985	9,464	17,741	22,688	19,617	12,563
Total	**20,926**	**36,384**	**39,273**	**54,433**	**43,748**	**52,385**

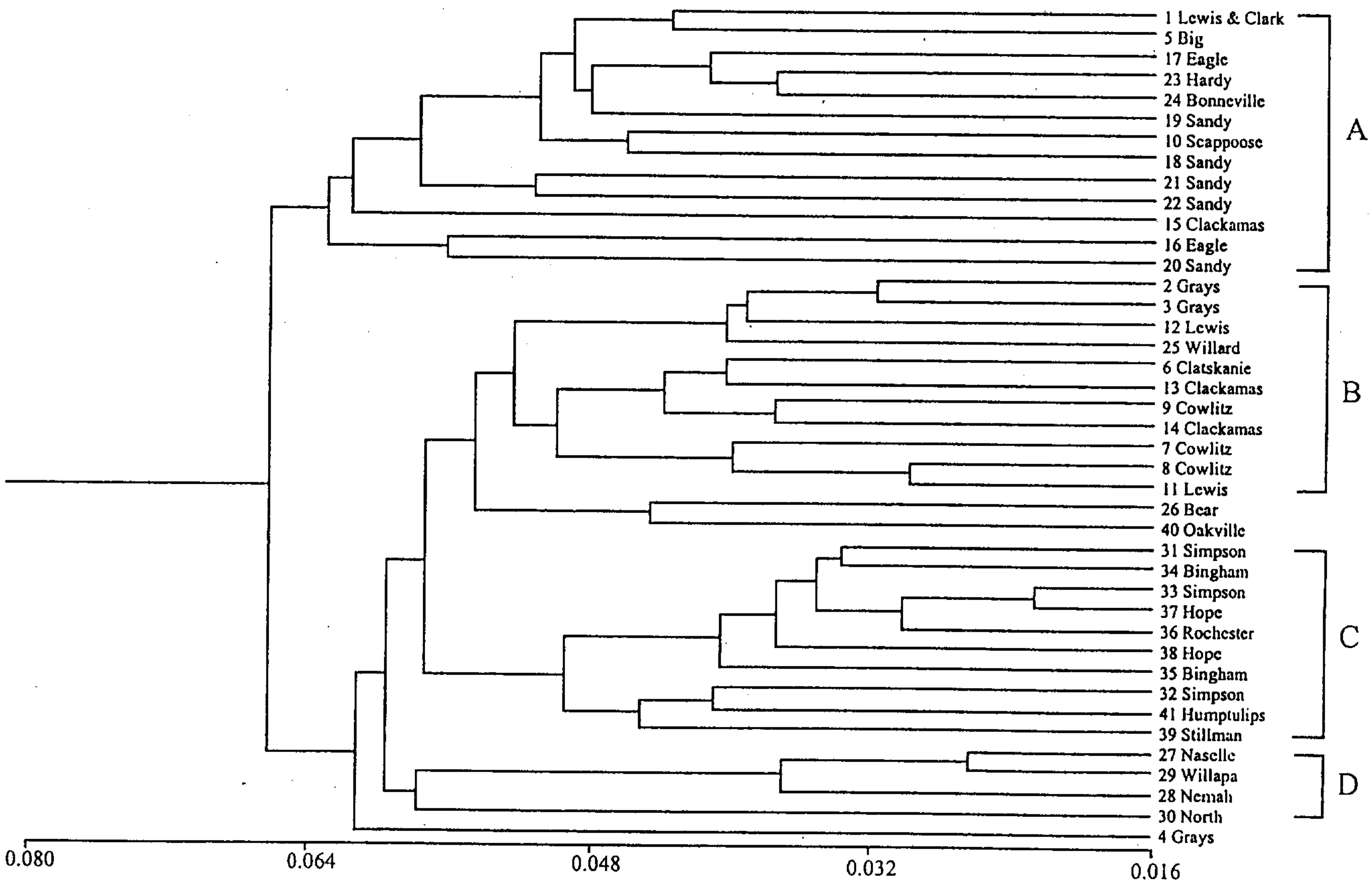


Figure 1. Dendrogram based on unweighted pair-group method analysis (UPGMA) clustering of pairwise chord distance values (Cavalli-Sforza and Edwards 1967) among 41 samples of coho salmon. Analysis was based on 53 gene loci. Numeric codes correspond to those in Table 2. Geographic clusters: A and B = lower Columbia River; C and D = southwest Washington coast.

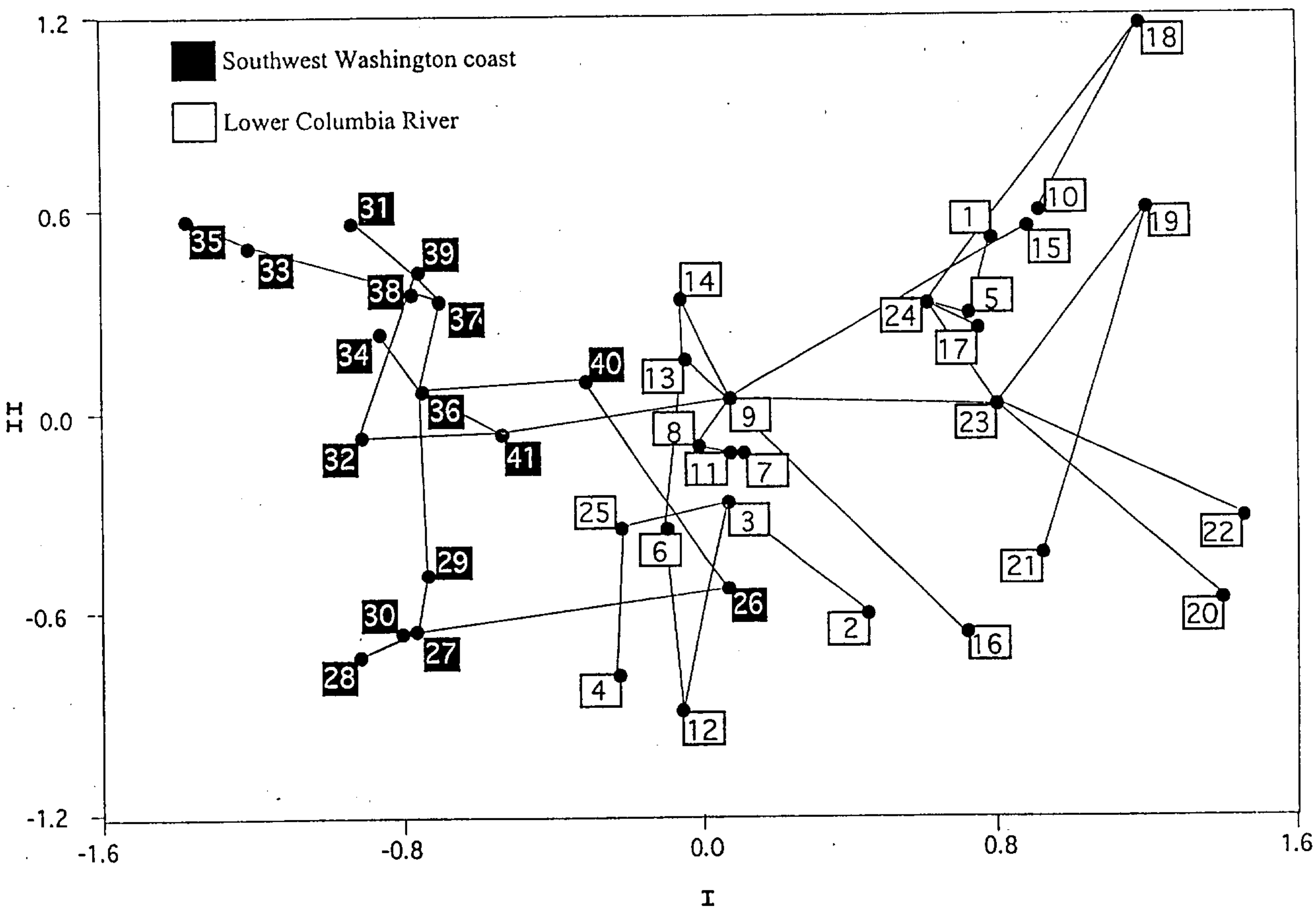


Figure 2. Multidimensional scaling and minimum spanning tree of pairwise chord distance values (Cavalli-Sforza and Edwards 1967) among 41 samples of coho salmon from lower Columbia River and southwest Washington coast. Analysis was based on data for 53 gene loci. Numeric codes correspond to those in Table 2. Samples from lower Columbia River populations are identified by white squares; those from southwest Washington populations are identified by black squares.

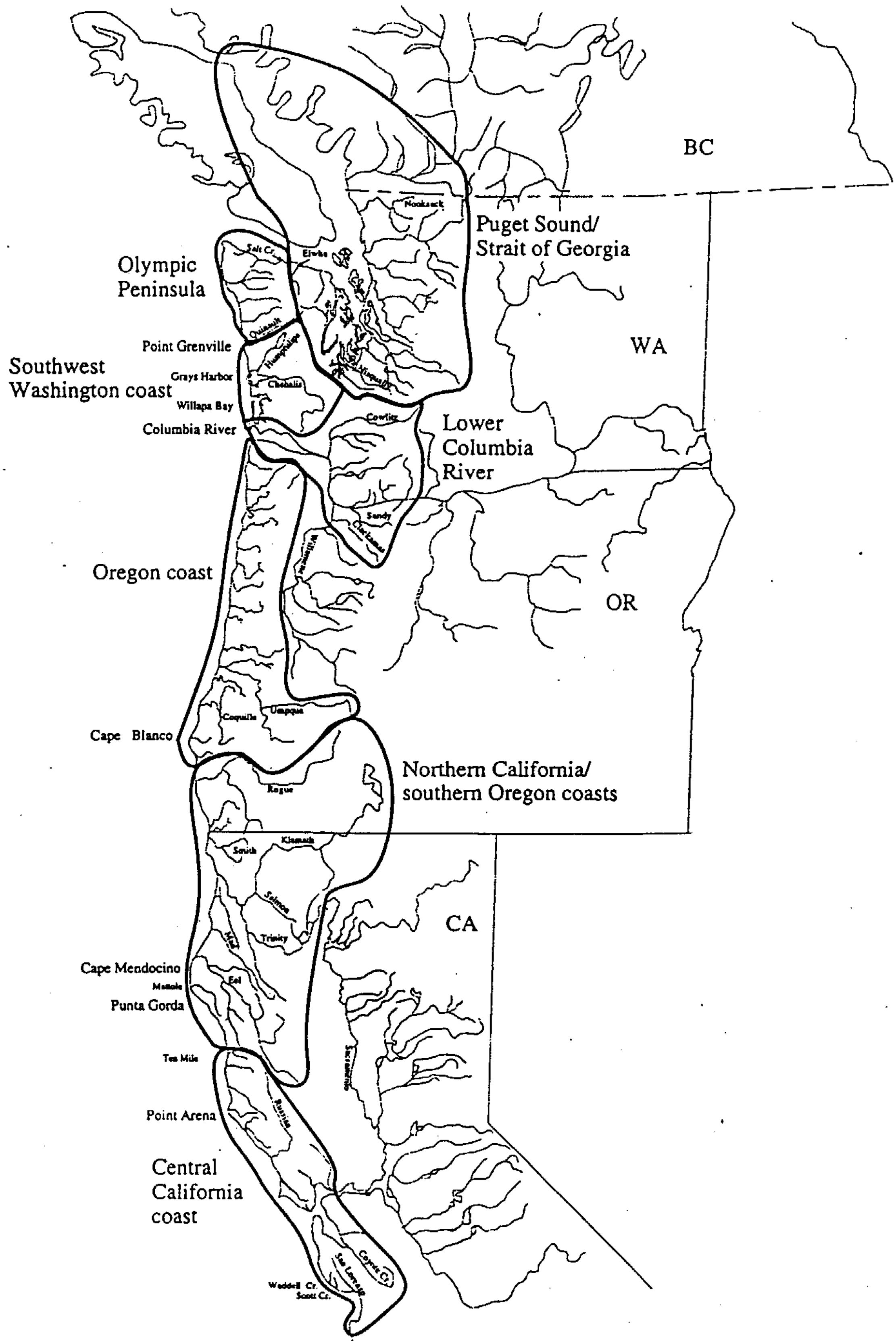


Figure 3. Proposed west coast coho salmon evolutionarily significant units.

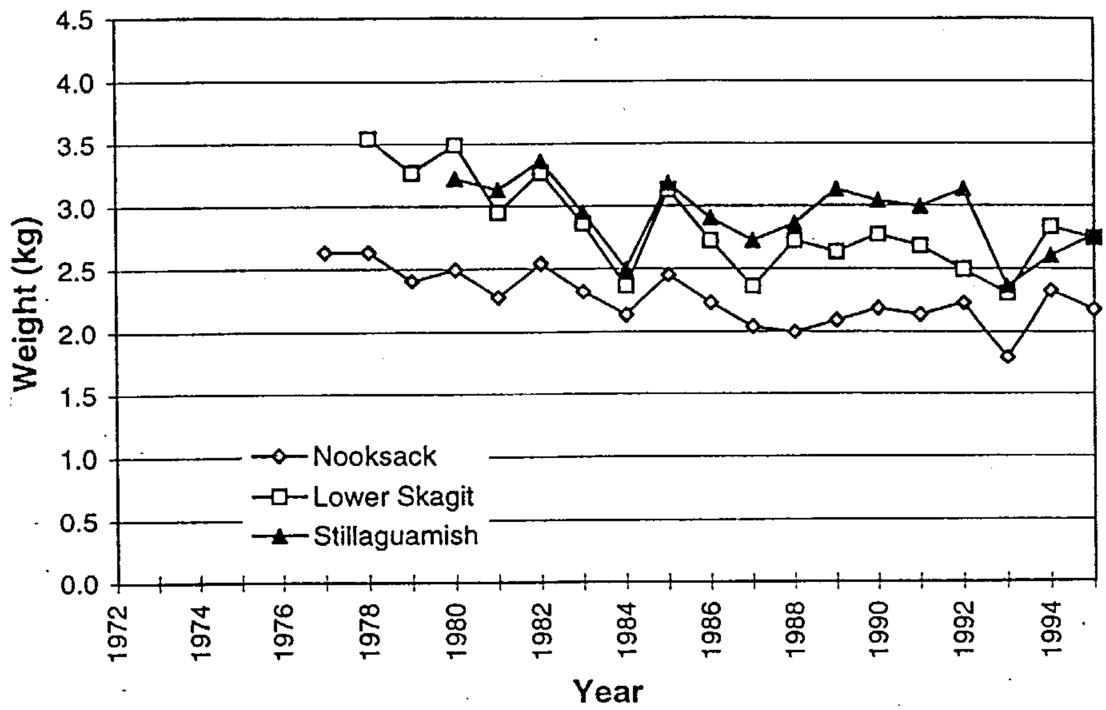


Figure 4. Mean weight (kg) of coho salmon caught in in-river fisheries in selected north Puget Sound rivers, 1972-95. Data from WDFW 1996b.

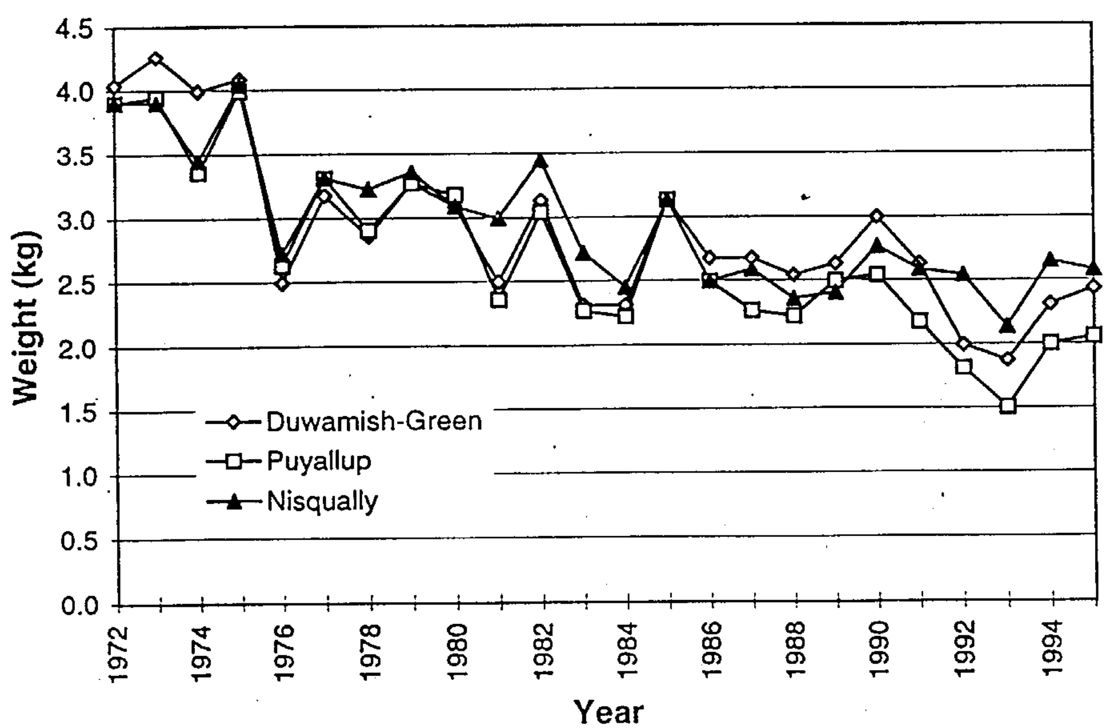


Figure 5. Mean weight (kg) of coho salmon caught in in-river fisheries in selected south Puget Sound rivers, 1972-95. Data from WDFW 1996b.

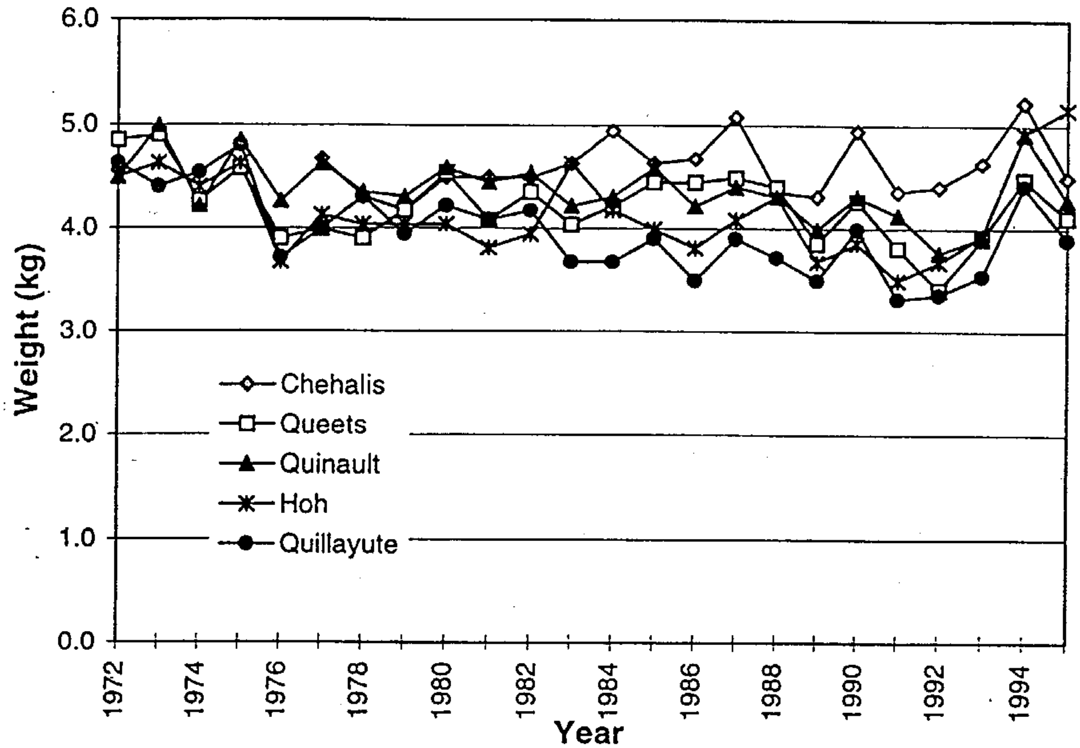


Figure 6. Mean weight (kg) of coho salmon caught in in-river fisheries in selected Washington coastal rivers, 1972-95. Data from WDFW 1996b.

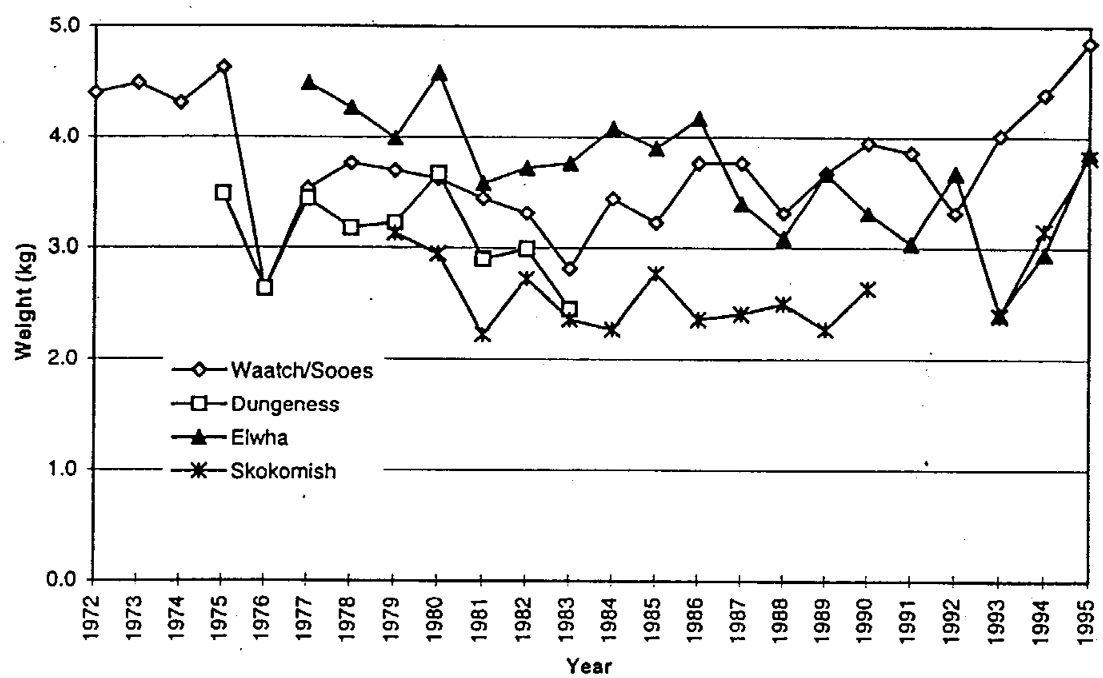
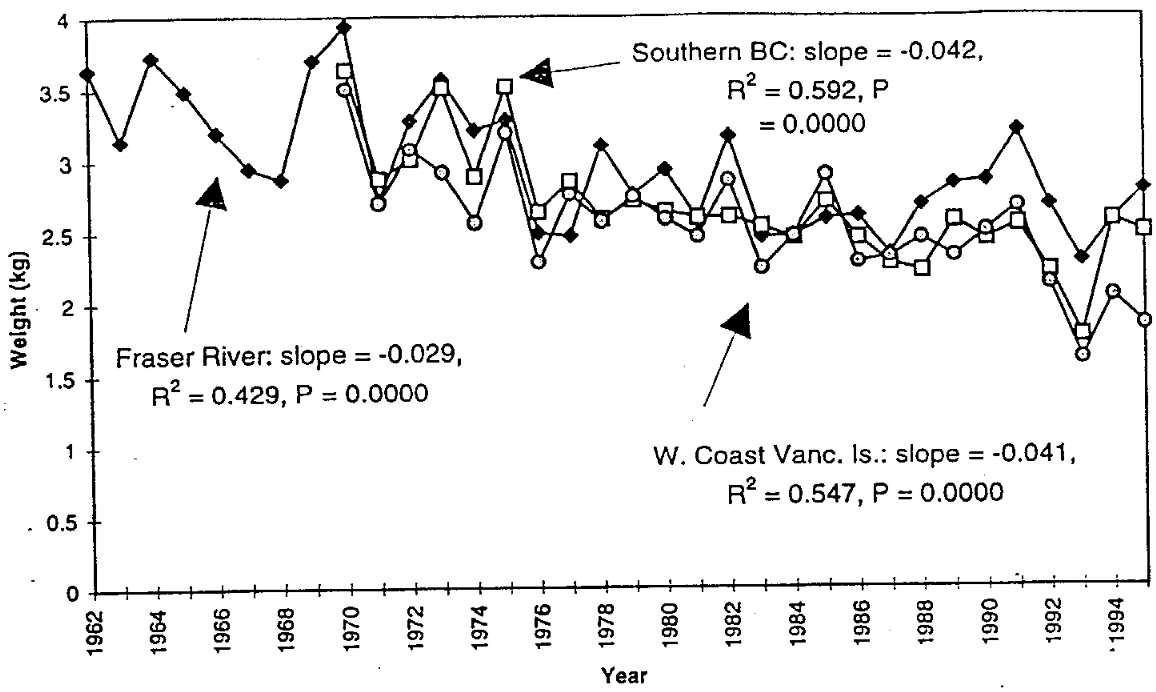


Figure 7. Mean weight (kg) of coho salmon caught in in-river fisheries in selected Washington coastal, Strait of Juan de Fuca, and Hood Canal rivers, 1972-95. Data from WDFW 1996b.



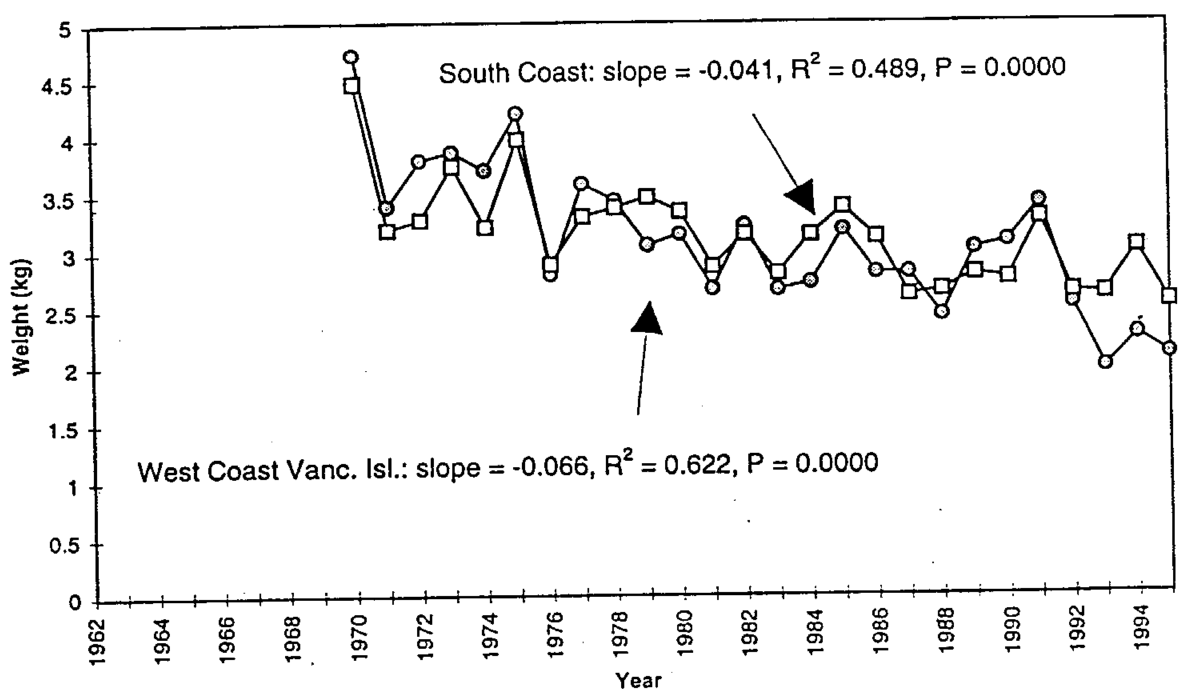


Figure 8. Mean weight (kg) of coho salmon caught in southern British Columbia fisheries. Weights are averaged over the entire season (top) or only for fish caught in Septmenber (bottom). Data from Canadian Department of Fisheries and Oceans (1996) and International North Pacific Fisheries Commission (1962-1996).

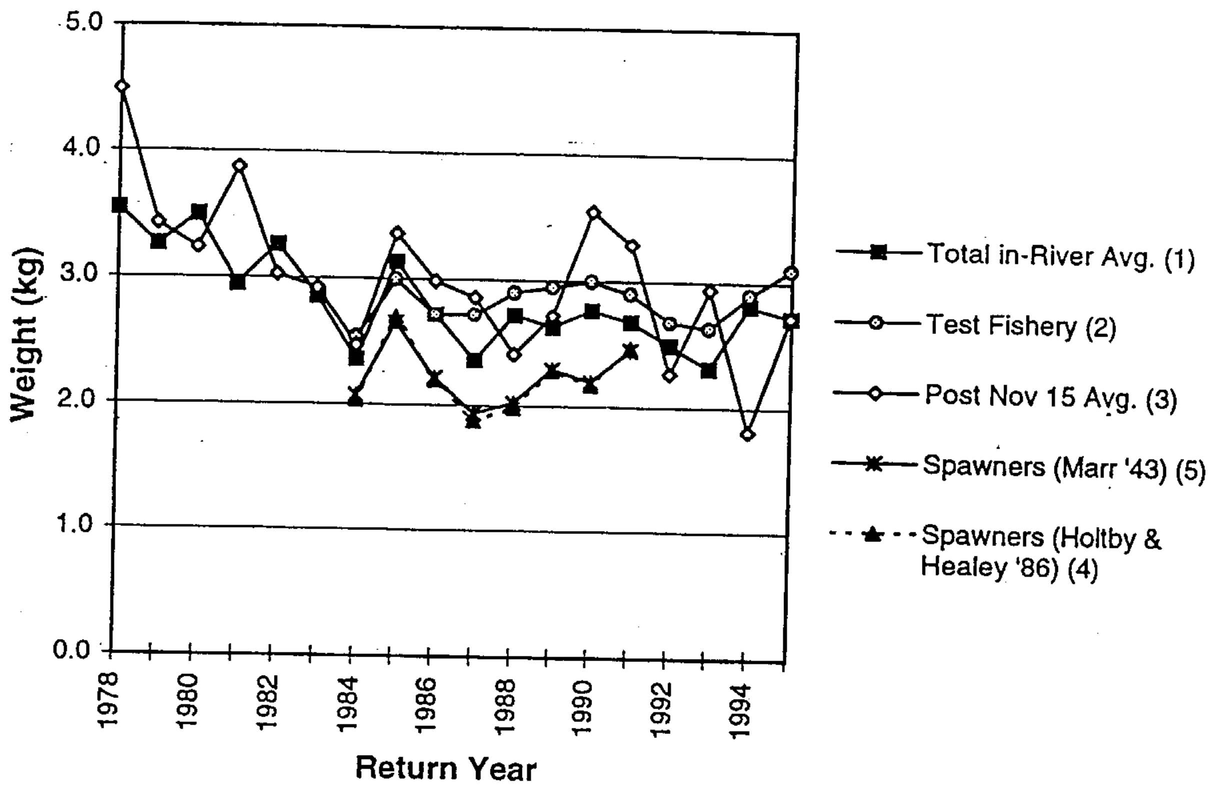


Figure 9. Comparison of average weight (kg) of Skagit River coho salmon caught in in-river fisheries and estimated weight of fish measured on the spawning grounds. Weights of fish caught in fisheries represent (1) the average weight over the entire season, (2) average weight of fish caught in test fisheries, and (3) fish caught in in-river fisheries after Nov 15. Lengths of fish measured on the spawning grounds were converted to weight using formulas provided by (4) Holtby and Healey (1986) or (5) Marr (1943). Data from WDFW 1996, Hayman 1996.

Appendix Table 2. Continued.

ESU / Basin/Stock	Recent abundance (5-yr geom. mean) Escape-ment	Run Size	Recent Trends (most recent 10 yr) Data Years	Escapement % a.c.	(s.e.)	Run Size % a.c.	(s.e.)	Recruits-per-Spawner % a.c.	(s.e.)	Long-Term Trends (all years with complete data) Escapement Years	% a.c.	(s.e.)	Run Size Years	% a.c.	(s.e.)	Recruits-per-Spawner Years	% a.c.	(s.e.)
Oregon Coast	44,553	71,918																
North/Mid Coast GCG	*15,093*	*26,206*	*1986-95*	*-4.8*	*(4.3)*	*-14.7*	*(3.8)*	*-12.4*	*(5.5)*	*1950-95*	*-2.3*	*(0.5)*	*1978-95*	*-9.1*	*(1.5)*	*1978-95*	*-9.8*	*(2.0)*
Nehalem			1986-95	-7.7	(7.5)	-17.3	(7.1)	-16.9	(12.2)	1950-95	-2.9	(0.7)	1978-95	-9.6	(2.7)	1979-95	-10.1	(4.9)
Tillamook			1986-95	-9.2	(9.5)	-18.6	(6.4)	-3.3	(10.0)	1950-95	-3.0	(1.0)	1978-95	-15.4	(2.2)	1978-95	-8.9	(3.6)
Nestucca			1986-95	2.8	(6.2)	-7.9	(3.8)	7.6	(8.9)	1950-95	-2.2	(1.6)	1978-95	-10.0	(2.2)	1980-95	-10.4	(4.2)
Siletz			1986-95	-9.3	(7.8)	-18.8	(6.1)	-12.2	(4.4)	1980-95	-5.9	(3.4)	1980-95	-13.4	(3.0)	1983-95	-11.1	(2.7)
Yaquina			1986-95	7.8	(6.6)	-3.4	(4.3)	-9.7	(7.4)	1950-95	-2.3	(1.1)	1978-95	-3.9	(2.7)	1979-95	-11.4	(6.1)
Alsea			1986-95	-13.7	(5.5)	-22.7	(6.0)	-21.9	(6.9)	1950-95	-2.4	(0.7)	1978-95	-10.7	(2.8)	1978-95	-13.2	(3.0)
Siuslaw			1986-95	-8.7	(4.9)	-18.2	(5.3)	-17.0	(6.3)	1950-95	-0.5	(0.7)	1978-95	-6.9	(2.5)	1978-95	-6.6	(2.6)
Umpqua GCG	*5,148*	*11,521*	*1986-95*	*1.4*	*(5.2)*	*-14.9*	*(6.7)*	*-20.7*	*(7.0)*	*1950-95*	*-2.3*	*(0.8)*	*1983-95*	*-0.2*	*(6.5)*	*1983-95*	*-8.4*	*(6.3)*
Lower Umpqua			1986-95	1.3	(5.5)	-15.0	(6.9)	-20.4	(7.5)	1950-95	-1.7	(8.0)	1983-95	-0.3	(6.6)	1983-95	-8.9	(6.5)
Upper Umpqua			1986-95	12.7	(11.3)	-5.4	(11.1)	-27.2	(13.2)	1981-95	31.5	(15.0)	1984-95	9.1	(10.4)	1987-95	-27.2	(13.2)
Mid/South Coast	*23,087*	*32,320*	*1986-95*	*8.5*	*(3.4)*	*-5.8*	*(4.6)*	*-5.4*	*(3.6)*	*1950-95*	*-2.2*	*(0.6)*	*1983-95*	*-4.7*	*(3.4)*	*1983-95*	*-5.6*	*(3.4)*
Coastal Lakes			1986-95	1.1	(7.0)	-12.2	(5.4)	-1.8	(9.6)	1970-95	-3.5	(1.4)	1983-95	-10.6	(3.5)	1983-95	-4.7	(5.6)
Coos			1986-95	13.6	(7.2)	-1.4	(4.0)	-5.7	(6.2)	1950-95	-1.8	(0.7)	1983-95	1.7	(3.0)	1983-95	2.7	(5.0)
Coquille			1986-95	2.3	(5.0)	-11.1	(6.7)	-8.5	(5.0)	1950-95	-2.5	(0.6)	1983-95	-9.4	(4.6)	1983-95	-11.2	(4.1)
N Califorina/S Oregon																		
Rogue	1,420	1,642	1986-95	5.7	(13.6)	-1.5	(13.1)	-6.2	(17.3)	1980-95	2.5	(6.5)	1980-95	-6.4	(5.4)	1982-95	-5.7	(8.7)
Central California																		

Appendix Table 2. Continued.

ESU / Basin/Stock	Recent abundance (5-yr geom. mean) Escapement	Run Size	Recent Trends (most recent 10 yr) Data Years	Escapement % a.c.	(s.e.)	Run Size % a.c.	(s.e.)	Recruits-per-Spawner % a.c.	(s.e.)	Long-Term Trends (all years with complete data) Escapement Years	% a.c.	(s.e.)	Run Size Years	% a.c.	(s.e.)	Recruits-per-Spawner Years	% a.c.	(s.e.)
Olympic Peninsula	20,671	41,672																
Misc Straits	3,627	6,185	1986-95	-6.1	(4.3)	-6.1	(4.6)	-9.5	(4.0)	1965-95	-2.3	(0.9)	1976-95	-5.0	(1.8)	1976-95	-2.5	(2.5)
Quinault	3,167	7,828	1986-95	-2.1	(8.5)	-14.2	(11.0)	-10.5	(8.4)	1977-95	-0.5	(2.9)	1982-95	-10.3	(4.6)	1982-95	-10.4	(6.6)
Queets	4,144	7,564	1986-95	-4.4	(5.5)	-12.7	(7.2)	-8.6	(6.4)	1976-95	2.3	(2.3)	1982-95	-6.6	(3.4)	1982-95	-6.9	(4.2)
Hoh	2,484	4,990	1986-95	-6.4	(4.7)	-13.0	(6.3)	-11.7	(5.5)	1976-95	-0.2	(1.9)	1982-95	-8.1	(3.1)	1982-95	-9.6	(3.7)
Quillayute summer	755	1,436	1986-95	0.9	(4.9)	-8.7	(4.2)	-10.0	(6.7)	1976-95	-2.9	(1.4)	1982-95	-11.5	(3.4)	1982-95	-9.5	(2.2)
Quillayute fall	6,493	13,668	1986-95	-7.0	(2.8)	-14.9	(5.4)	-11.3	(4.2)	1976-95	-0.1	(1.9)	1982-95	-6.1	(2.8)	1982-95	-5.1	(3.9)
Lower Columbia	2,194	3,802*																
Clackamas	957	1,500*	1986-95	-0.4	(10.6)					1967-95	4.7	(2.5)						
Clackamas late	612	1,014	1986-95	-12.3	(10.5)	-21.5	(8.9)	-22.3	(6.2)	1957-95	-0.9	(1.1)	1957-95	-4.0	(1.3)	1960-95	-6.0	(2.2)
Sandy	625	1,288	1986-95	-13.5	(6.1)	-28.5	(5.8)	-16.6	(5.5)	1960-95	0.3	(1.1)	1960-95	-0.9	(1.5)	1963-95	-0.4	(1.7)
SW Washington	29,099	52,455																
Grays Harbor	*29,099*	*52,455*	*1986-95*	*-1.3*	*(5.5)*	*-6.9*	*(5.9)*	*-11.1*	*(7.7)*	*1970-95*	*-1.9*	*(1.7)*	*1970-95*	*-2.9*	*(4.2)*	*1986-95*	*-11.1*	*(7.7)*
Humptulips	4,062	7,316	1986-95	-1.3	(4.8)	-7.8	(5.8)	-3.0	(9.4)	1983-95	-3.5	(4.0)	1983-95	-4.9	(4.1)	1986-95	-3.0	(9.4)
Chehalis	24,328	44,338	1986-95	-1.4	(6.5)	-6.8	(6.3)	-12.5	(8.2)	1983-95	-0.6	(4.6)	1983-95	-2.6	(4.4)	1986-95	-12.5	(8.2)

* Run size of 1,500 for Clackamas early run is assumed.

Appendix Table 2. Summary of recent status information for west coast coho salmon stocks. Blanks indicate insufficient data. Stocks in italics represent aggregates of those below them.

ESU	Recent abundance (5-yr geom. mean)		Recent Trends (most recent 10 yr)							Long-Term Trends (all years with complete data)								
Basin/Stock	Escape-ment	Run Size	Data Years	Escapement		Run Size		Recruits-per-Spawner		Escapement			Run Size			Recruits-per-Spawner		
				% a.c.	(s.e.)	% a.c.	(s.e.)	% a.c.	(s.e.)	Years	% a.c.	(s.e.)	Years	% a.c.	(s.e.)	Years	% a.c.	(s.e.)
Puget Sound/Strait of Georgia	162,874	445,045																
North Puget Sound	*114,002*	*274,916*	*1986-95*	*-2.0*	*(4.0)*	*-7.2*	*(2.3)*	*-1.3*	*(4.2)*	*1965-95*	*1.1*	*(0.7)*	*1976-95*	*-2.6*	*(1.1)*	*1976-95*	*-2.4*	*(1.5)*
Misc 7A Streams	414	704	1986-95	-2.6	(1.4)	-2.5	(2.2)	-1.3	(2.7)	1965-95	1.4	(0.9)	1976-95	1.1	(1.1)	1976-95	-1.6	(1.3)
Nooksack River	631	5,443	1986-95	-6.0	(8.0)	-13.5	(6.2)	-2.5	(10.3)	1965-95	-4.4	(1.3)	1976-95	-6.5	(2.6)	1976-95	0.1	(3.9)
Samish River	9,401	35,423	1986-95	6.4	(4.4)	2.0	(3.8)	0.5	(4.6)	1965-95	8.1	(1.3)	1976-95	3.7	(2.1)	1976-95	-6.7	(2.3)
Skagit River	12,504	25,220	1986-95	-9.6	(5.3)	-12.8	(4.0)	1.4	(7.2)	1965-95	-0.5	(1.0)	1976-95	-5.5	(1.5)	1976-95	-4.1	(2.1)
Stillaguamish River	11,480	27,893	1986-95	-1.1	(6.9)	-9.6	(3.9)	-0.3	(8.4)	1965-95	-0.9	(1.0)	1976-95	-5.0	(1.4)	1976-95	-0.7	(2.6)
Snohomish River	77,065	174,961	1986-95	-0.7	(4.3)	-6.2	(2.7)	-1.8	(5.0)	1965-95	1.6	(0.8)	1976-95	-2.0	(1.2)	1976-95	-2.2	(1.7)
Misc Area 9 Streams	437	744	1986-95	-6.1	(6.1)	-6.0	(5.6)	-7.6	(7.6)	1965-95	-1.8	(1.3)	1976-95	-6.0	(1.9)	1976-95	-4.0	(3.0)
South Puget Sound	*22,339*	*122,683*	*1986-95*	*-1.3*	*(4.7)*	*-16.0*	*(4.4)*	*-7.3*	*(5.3)*	*1965-95*	*-1.8*	*(0.8)*	*1976-95*	*-2.8*	*(2.1)*	*1976-95*	*-0.2*	*(1.6)*
Misc 10 -Seattle	470	977	1986-95	4.9	(9.0)	-0.8	(7.0)	12.4	(10.1)	1965-95	0.6	(1.3)	1976-95	-0.5	(2.1)	1976-95	-0.1	(2.8)
Lake Washington	1,064	2,931	1986-95	-22.4	(7.9)	-36.7	(7.4)	-19.7	(8.3)	1965-95	-7.2	(1.4)	1976-95	-15.3	(3.4)	1976-95	-6.5	(2.8)
Misc 10E -Port Orch	1,271	9,954	1986-95	5.0	(8.6)	-15.2	(5.6)	-5.4	(8.5)	1965-95	0.6	(1.3)	1976-95	7.5	(3.1)	1976-95	8.1	(3.4)
Green-Duwamish	2,743	10,744	1986-95	3.7	(7.6)	-9.3	(5.9)	1.1	(8.8)	1965-95	-2.1	(1.2)	1976-95	-3.0	(1.8)	1976-95	-2.0	(2.5)
Misc 11 -Tacoma	310	708	1986-95	0.5	(10.7)	-8.8	(8.5)	4.3	(13.5)	1965-95	-0.1	(1.4)	1976-95	-2.2	(2.6)	1976-95	-0.5	(3.5)
Puyallup River	4,129	16,259	1986-95	6.7	(7.9)	-16.2	(7.2)	-15.4	(6.1)	1965-95	-2.6	(1.3)	1976-95	-6.7	(2.4)	1976-95	-5.3	(2.5)
Nisqually River	2,505	7,734	1986-95	11.2	(9.5)	-13.8	(7.0)	-5.3	(10.0)	1965-95	0.0	(1.6)	1976-95	-5.8	(3.3)	1976-95	-4.1	(4.0)
Misc 13 -S. Pug Snd	512	1,826	1986-95	-0.7	(5.1)	-11.6	(6.5)	-9.6	(7.8)	1965-95	0.4	(1.1)	1976-95	0.7	(2.9)	1976-95	0.7	(3.1)
Misc 13A -Carr Inlet	164	585	1986-95	-6.2	(6.6)	-19.2	(7.1)	-13.3	(9.1)	1965-95	-3.6	(1.0)	1976-95	-11.2	(2.3)	1976-95	-6.3	(2.6)
Misc 13B Streams	4,719	45,903	1986-95	0.0	(5.5)	-8.9	(4.5)	-4.6	(7.8)	1965-95	0.7	(1.4)	1976-95	4.4	(2.5)	1976-95	4.6	(2.6)
Chambers Creek	264	1,569	1986-95	2.0	(6.3)	-14.0	(4.8)	-14.0	(7.8)	1965-95			1976-95	4.0	(3.2)	1976-95	5.0	(3.9)
Deschutes River	994	9,693	1986-95	-22.9	(6.8)	-29.2	(8.5)	-13.1	(11.0)	1965-95	0.5	(1.8)	1976-95	-2.7	(4.4)	1976-95	-1.1	(3.7)
Hood Canal	*26,533*	*47,447*	*1986-95*	*7.3*	*(7.5)*	*-4.2*	*(6.7)*	*3.3*	*(8.2)*	*1965-95*	*1.1*	*(1.2)*	*1976-95*	*-4.1*	*(1.8)*	*1976-95*	*-3.3*	*(2.3)*
Dabob Bay - Area 12	230	661	1986-95	-7.3	(3.6)	-25.6	(6.6)	-12.3	(6.3)	1965-95	-6.4	(1.3)	1976-95	-14.1	(2.6)	1976-95	-4.3	(2.5)
N. Hood Canal	2,080	3,559	1986-95	10.1	(8.5)	4.7	(8.0)	12.6	(10.9)	1965-95	2.2	(1.4)	1976-95	-0.6	(2.1)	1976-95	-0.9	(3.0)
Central Hood Canal	4,977	8,550	1986-95	11.0	(8.7)	4.7	(8.0)	12.0	(10.8)	1965-95	2.2	(1.3)	1976-95	-0.6	(2.1)	1976-95	-0.8	(2.9)
South Hood Canal	3,192	5,532	1986-95	4.4	(6.6)	-3.8	(6.0)	2.8	(8.9)	1965-95	1.6	(1.2)	1976-95	-3.4	(1.8)	1976-95	-3.7	(2.5)
Skokomish River	7,041	12,272	1986-95	11.2	(8.8)	-5.3	(8.5)	1.5	(9.1)	1965-95	2.3	(1.3)	1976-95	-3.8	(2.2)	1976-95	-4.0	(2.4)
SE Hood Canal	8,188	14,548	1986-95	4.5	(6.7)	-3.7	(5.9)	3.2	(8.9)	1965-95	1.5	(1.2)	1976-95	-3.7	(1.7)	1976-95	-3.9	(2.4)
Dungeness River	326	813	1986-95	-16.6	(3.3)	-26.4	(3.6)	-15.5	(4.1)	1965-95	-6.9	(0.9)	1976-95	-14.2	(2.0)	1976-95	-5.8	(2.3)

[d] Reflects naturally spawning fish only.

[e] For California basins, this value is salmon-accessible miles of habitat, estimated in the 1960s. For Oregon basins, this is current miles of spawning habitat except the Clackamas which is total river length. For Washington basins, the first (or only) value is the length of the mainstems, the second value is miles of tributaries, and entries marked with an asterisk are miles of salmon-accessible habitat.

[f] When ranges are given, these reflect the highest and lowest values from various subbasins within the basin. See Table 3 for more details and additional information.

[g] Number of fish sampled for scales or marks to determine the percent of hatchery fish spawning naturally.

[h] Overlap of spawning timing between wild and hatchery fish is considered "high" if the peak timings substantially overlap, "moderate" if several weeks separate the two timings, and "low" if over a month separates the timings.

[i] Facility no longer in operation or no longer producing coho salmon.

[j] Releases provided are from the hatchery(ies) located in that basin and do not include releases by hatcheries from outside the basin.

[k] Includes releases from Cascade, Oxbow, Carson and Wakeena Pond Hatcheries.

[l] Little Quilcene River only

[m] NF Skokomish River only

Appendix Table 1. Cont.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawning naturally[f]	Total no. fish sampled[g]	Wild/ hatch. spawn timing overlap[h]
Puget Sound/Strait of Georgia ESU, cont.														
Stillaguamish	Y	9(1)	11,714	<1	32	4(3?)	95	88	9	11,480	117/860	?		?
Skagit	Y	7(3)	59,610	94	56	4(3)	7,664	100	44	12,504	362/2168	1	259-	high
Samish	Y	9(1)	16,861	64	77	1(1)	64	100	<1	9,401	44/115	?		low
Nooksack	Y	11(3)	53,080	68	55	6(3)	27,156	73	48		124/710	?		mod.
Lummi net-pens			10,271	0	100		10,067		100					
Fraser[j]	Y	?	6,547	?	78	?	29,185	?	94			59	3350	?
Capilano[j]	Y	2(1)	10,477	95	63	2(1)	5,146	100	89			?		?
Powell R[j]	Y	2(1)	184	8	<1	4(3?)	1,824	11	24			?		?
Campbell[j]	Y	1(1)	92	100	25	1(1)	286	100	62			?		?
Quinsam[j]	Y	1(1)	13,831	100	84	2(1)	11,859	100	82			<1		?
Black Cr	N	0	0			0	0					<1		?
Puntledge[j]	Y	2(1?)	18,205	100	29	3(2?)	15,002	100	42			0-6		?
Trent	N	3(1)	714	34	<1	2(1)	304	77	<1			31		?
Rosewall Cr[j]	Y	3(1)	316	30	72	4(0)	142	0	100			1		?
Qualicum[j]	Y	1(1)	21,842	100	63	1(1)	11,258	100	93			0.1-1.1		?
Englishman R[j]	Y	0	0			3(1)	729	52	1			?		?
Nanaimo[j]	Y	1(1)	987	100	<1	2(2?)	1,974	100	8			?		?
Cowicnan[j]	Y	1(1)	316	100	9	2(1)	2,063	94	1			?		?

[a] Includes egg-taking stations.

[b] Number in parenthesis indicates number of "native" stocks released (those whose name is the same as the basin name or a stream in the basin, e.g., Skagit and Clark Cr. are "native" to the Skagit River Basin)

[c] These value represent plants through 1993 for Columbia River, British Columbia, southwest Washington and California Cooperative hatcheries with the exception of Monterey Bay Salmon and Trout Project. All other plants are through 1995, except Quilcene, Makah, and Quinault NFHs which are through 1996.

Appendix Table 1. Cont.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawning naturally[f]	Total no. fish sampled[g]	Wild/ hatch. spawn timing overlap[h]
Puget Sound/Strait of Georgia ESU														
Elwha	Y	9(2)	18,311	73	90	3(2)	7,983	100	90	150?	5*	?		high
Morse Cr	N	6(0)	845	<1	67	1(0)	24	<1	<1			?		
Dungeness	Y	9(1)	33,055	94	56	2(1)	6,663	86	70	326	49/382	?		high
Discovery Bay	N	8(0)	1,723	<1	64	0	0			100?		?		
Port Gamble/Quilcene net-pens			2,998	0	100		4,980	0	100					
Quilcene	Y	8(1)	30,377	96	42	3(1)	8,096	99	69		31/242	90[l]	57	
Dosewallips	N	9(0)	1,308	<1	68	2(0)	58	<1	<1		55	96	23	
Duckabush	N	8(0)	1,336	<1	69	0	0				12/34	?		
Hamma Hamma	N	7(0)	1,764	<1	66	1(0)	65	<1	<1		18/93	?		
Skokomish	Y	11(1)	32,033	78	85	4(1)	6,403	89	58	7,041	34/158	5[m]	22	mod.
Union	N	6(0)	1,269	<1	33	1(0)	8	<1	<1			?		
Mission	N	5(0)	442	<1	50	0	0					?		
Dewatto	N	6(0)	1,795	<1	20	0	0					?		
Goldsborough Cr.	N	9(0)	5,160	<1	6	2(0)	3,686	<1	<1			?		
South sound net-pens			13,493	<1	100		21,035	<1	100					
Deschutes	N	10(0)	3,166	<1	17	1(0)	22	<1	5	994	49/257	2-8	64537	
Fox Island net-pens			4,041		100		2,347		100					
Nisqually	Y	8(0)	15,446	0	40	8(1)	14,715	<1	46	2,505	108/272	?		
Puyallup	Y	10(2)	63,720	71	55	7(2)	24,236	95	50	4,129	203/1043	?		high
Duwamish	Y	17(1)	64,475	85	54	6(2)	35,277	100	34	2,743	138/176	?		mod.-high
Elliot Bay net-pens			1,334		100		1,335		100					
L. Washington	Y	12(2)	62,964	83	55	7(2)	24,104	95	33	1,064	83/149	?		high
Snohomish	Y	14(3)	55,872	84	37	7(3)	12,389	98	28	77,065	374/1752	<1	5569	mod.-high
Agate Pass net-pens			922		100		3,925		100					

Appendix Table 1. Cont.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawning naturally[f]	Total no. fish sampled[g]	Wild/ hatch. spawn timing overlap[h]
Olympic Peninsula ESU														
Lyre	N	5(0)	1,022	<1	55	1(0)	20	<1	<1			?		
Pysht	N	6(0)	1,828	<1	30	1(0)	82	<1	<1		15/23	?		
Hoko	Y	7(0)	1,885	<1	25	1(0)	811	<1	47		28/14	?		
Sekiu	N	5(0)	1,167	<1	10	1(0)	127	<1	<1		9/12	?		
Waatch	N	4(0)	2,974	<1	63	4(0)	1,490	<1	43		6*	?		
Sooes	Y	6(1)	5,056	3	81	3(1)	5,390	67	62		13/14	?		
Ozette	N	3(0)	1,666	<1	2	0	0				52	?		
Quillayute	Y	10(3)	33,543	80	59	4(4)	16,882	100	55	7,248	374	?		high
Goodman Cr	N	3(0)	2,404	<1	5	0	0				36*	?		
Hoh	Y	6(1)	1,766	12	90	3(1)	576	84	74	2,484	32/34	?		
Queets	Y	10(1)	7,617	6	81	6(3)	10,232	59	78	4,144	26/68	?		?
Raft	N	6(0)	4,185	<1	25	4(0)	607	<1	11		43	?		
Quinault	Y	15(2)	28,566	81	50	4(2)	12,222	88	61	3,167	55/143	?		?

Appendix Table 1. Cont.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawning naturally[f]	Total no. fish sampled[g]	Wild/ hatch. spawn timing overlap[h]
Columbia River/Southwest Washington coast ESU														
Youngs[j]	Y	3(0)	324	<1	44	5(0)	9,408	<1	97			many?		
Klaskanine[j]	Y[i]	8(1)	58,189	56	56	5(1)	17,323	72	93			many?		
Big Cr[j]	Y	5(1)	45,772	80	47	1(1)	5,725	100	88			many?		
Clackamas[j]	Y	5(1)	34,737	77	81	6(1)	17,742	62	99		83	many?		
Sandy[j]	Y	7(1)	54,049	46	46	1(1)	8,400	100	94	690		many?		
Tanner Cr[j]	Y	9(2)	74,791	42	52	2(1)	16,201	86	65			many?		
Columbia tribs[j, k]	Y	13(3)	88,162	26	55	2(0)	24,919	<1	98			many?		
Hood	N	3(0)	453	<1	<1	0	0					many?		
White Salmon[j]	Y	6(1)	47,225	35	61	1(1)	5,087	100	<1		38	many?		
Wind[j]	Y	5(1)	58,411	2	82	5(2)	28,412	22	80		26	many?		
Washougal[j]	Y	7(1)	90,290	54	71	3(0)	23,080	<1	72		36	many?		
Lewis[j]	Y	10(2)	93,895	50	66	5(1)	59,127	2	69		110	many?		
Kalama[j]	Y	10(2)	66,506	57	66	4(1)	17,526	<1	69		43	many?		
Cowlitz[j]	Y	5(2)	198,802	99	54	3(2)	67,293	95	63		133	many?		
Elochoman[j]	Y	14(1)	65,656	48	82	4(1)	15,871	11	84		15	many?		
Chinook[j]	Y	7(1)	9,445	1	<1	5(1)	4,102	8	<1		8	many?		
Grays[j]	Y	7(1)	43,222	50	60	3(1)	11,856	<1	63		16	many?		
Bear	N	5(0)	1,802	<1	24	1(0)	1,157	<1	1		13/16	many?		
Naselle	Y	12(2)	28,461	40	53	4(1)	21,736	97	75		99/59	many?		
Nemah	Y	8(1)	22,522	90	80	3(1)	9,008	90	76		29/49	many?		low-mod
Willapa	Y	10(1)	26,684	56	72	5(1)	10,428	86	51		131/320	many?		low-mod
North	N	7(0)	7,098	<1	36	3(0)	4,503	<1	5		32/109	many?		
Johns	N	6(0)	838	<1	69	2(0)	575	<1	<1	962	8/26	3	213	
Chehalis	Y	18(2)	100,747	68	53	2(1)	46,131	83	24	48,942	425/835	17	299	low-mod
Hoquiam	N	8(0)	1,865	<1	40	2(0)	1,093	<1	<1	3,356	68	4	308	
Humptulips	Y	11(1)	18,893	58	74	2(1)	17,112	97	72	8,172	58/102	80	288	high
Copalis	N	1(0)	100	<1	100	1(0)	100	<1	<1			?		
Moclips	N	4(0)	1,465	<1	12	3(0)	513	<1	<1			?		

Appendix Table 1. Cont.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawning naturally[f]	Total no. fish sampled[g]	Wild/hatch. spawn timing overlap[h]
Oregon Coast ESU														
New/Floras	N	5(0)	2,416	0	9	0	0			1,500	38	14	41	--
Coquille	Y	4(1)	3,709	77	7	1(1)	901	100	23	4,200	333.5	7-20	381	high
Coos	Y[i]	10(1)	5,591	53	29	1(1)	620	100	15	7,410	224	6-23	736	high
Coos Commercial		19(1)	32,204	5	100	5(1)	6,047	75						--
Tenmile	N	3(1)	1,205	12	14	3(2)	3,973	98	22	3,350	69	<1	169	--
Umpqua	Y	4(1)	4,220	95	64	2(2)	3,987	100	45	5,670	1178	0-35	612	high
Tahkenitch	N	2(0)	259	<1	<1	1(1)	2	<1	100	1,040	22	5	569	--
Siltcoos	N	1(0)	50	<1	<1	0	0			2,400	50	8	331	--
Siuslaw	N	6(0)	11,257	<1	1	3(0)	667	<1	45	4,000	515	4-40	367	--
Yachats	N	1(0)	37	<1	<1	0	0			200	44	43	19	--
Alsea	Y	10(2)	30,539	84	67	2(2)	12,589	100	81	2,150	223	8-47	286	mod.
Beaver Cr.	N	4(0)	393	<1	34	0	0			320	19	<1	18	--
Yaquina	Y[i]	6(0)	473	<1	14	1(0)	306	<1	100	1,500	113	21	226	--
Yaquina Commercial		17(2)	81,922	39	100	4(2)	22,705	64						--
Siletz	Y[i]	5(1)	16,315	79	65	3(1)	8,902	97	80	1,020	191	61-79	309	high
Devils Lake	N	0	0			0	0			100	7	12	36	--
Salmon	Y	2(1)	1,710	99	84	1(1)	3,936	<1	48	220	42	79	656	high
Neskowin Cr.	N	1(0)	19	<1	<1	0	0			50	16	100	1	--
Sand Lake	N	2(0)	222	<1	<1	0	0			40	11	33	3	--
Nestucca	Y[i]	6(1)	1,641	2	38	1(0)	101	<1	53	520	168	27	37	mod.
Tillamook	N	2(0)	414	<1	40	1(0)	50	<1	<1	180	47	69	15	--
Trask	Y	2(1)	29,570	100	50	1(1)	10,800	100	80	230	62	81	333	mod.
Wilson	N	2(0)	1,821	<1	42	0	0			270	71	38	27	--
Kilchis	N	1(0)	1,037	<1	53	0	0			160	43	59	20	--
Miami	N	5(0)	1,130	<1	49	0	0			70	19	56	5	--
Nehalem	Y	3(1)	21,594	92	72	2(2)	7,832	<1	78	2,200	385	35-89	635	low
Ecola Cr.	N	0	0			0	0			50	8	44	8	--
Necanicum	N	3(0)	939	<1	56	0	0			500	52	42	34	--

Appendix Table 1. Cont.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawning naturally[f]	Total no. fish sampled[g]	Wild/ hatch. spawn timing overlap[h]
Northern California/southern Oregon coasts ESU														
Mattole	N	0	0			1(1)	21	100	58	760	187	?		high?
Bear	N	1(0)	41	<1	<1	0	0					?		high?
Eel	N	7(1)	1,067	5	82	5(2)	67	23	4	2,040	894	?		high?
Elk	N	4(0)	280	<1	100	0	0					?		high?
Freshwater Cr	Y	3(0)	254	<1	45	3(1)	268	99	96			?		high?
Mad	Y	10(1)	3,665	21	69	4(1)	1,466	22	99	460	84	?		high?
Redwood Cr	Y	3(1)	76	14	100	1(1)	65	100	69	280	110	high		high?
Klamath	Y	9(2)	16,184	80	50	5(3)	7,540	100	88	1,860	813	?-100		high?
Smith	Y	6(0)	780	<1	84	1(1)	36	100	89	820	348	?		high?
Winchuck	N	0	0			0	0					?		high?
Chetco	N	4(0)	78	<1	36	0	0				32.7	?		high?
Pistol	N	0	0			0	0				17.6	?		high?
Rogue	Y	8(1)	2,147	84	61	2(1)	2,900	100	69	2,500	518	?	0	?
Elk	N	0	0			0	0				8.1	?		

Appendix Table 1. Summary of key risk factors associated with artificial production for selected river basins in each coho salmon ESU.

Basin	Hatchery in basin?[a]	1950-1985 No. stocks[b] tot (nat)	1950-1985 No. fish planted (1,000s)	1950-1985 % native[b]	1950-1985 % smolts	Post 1985[c] No. stocks[b] tot (nat)	Post 1985[c] No. fish planted (1,000s)	Post 1985[c] % native[b]	Post 1985[c] % smolts	Total nat. spawner abund.[d] (recent)	Estim. habitat[e] (linear miles)	Percent hatch. fish spawn. natural.[f]	Total no. fish sampled[g]	Wild/hatch. spawn timing overlap[h]
Central California ESU														
San Lorenzo	N	4(0)	237	<1	100	4(1)	172	34	100	10-100	79	?		high?
Scott	Y	4(1)	60	50	50	2(1)	41	84	95	30-40	?	72	82	high?
Waddell	N	1(0)	10	<1	100	1(0)	8	<1	74	10-50	12	?		high?
Small streams south of San Francisco Bay	N	2(0)	85	<1	100	1(0)	6	100	<1	0	?	?		high?
S. F. Bay tribs	N	2(0)	12	<1	17	0	31	100	100	0	?	?		high?
Lagunitas Cr	N	5(0)	297	<1	76	2(1)	9	56	100	40	?	?		high?
Walker Cr	N	1(0)	18	<1	100	0	0			10s	?	?		high?
Salmon Cr	N	0	0			0	0			10s?	?	?		high?
Russian	Y	4(1)	548	15	68	7(2)	1,419	48	56	255	133	?		high?
Gualala	N	1(0)	190	<1	100	1(0)	74	<1	<1	200	75	?		high?
Garcia	N	3(0)	169	<1	70	1(0)	54	<1	<1	10s?	83	?		high?
Navarro	N	2(0)	204	<1	59	3(0)	0	<1	<1	300	103	?		high?
Albion	N	1(0)	45	<1	67	1(0)	0	<1	<1	?	?	?		high?
Big	N	4(0)	164	<1	92	0	0			280	101	?		high?
Noyo	Y	6(1)	2,180	63	97	1(1)	1,016	100	96	3,740	83	?		high?
Ten Mile	N	7(1)	913	1	70	0	0			160	103	?		high?

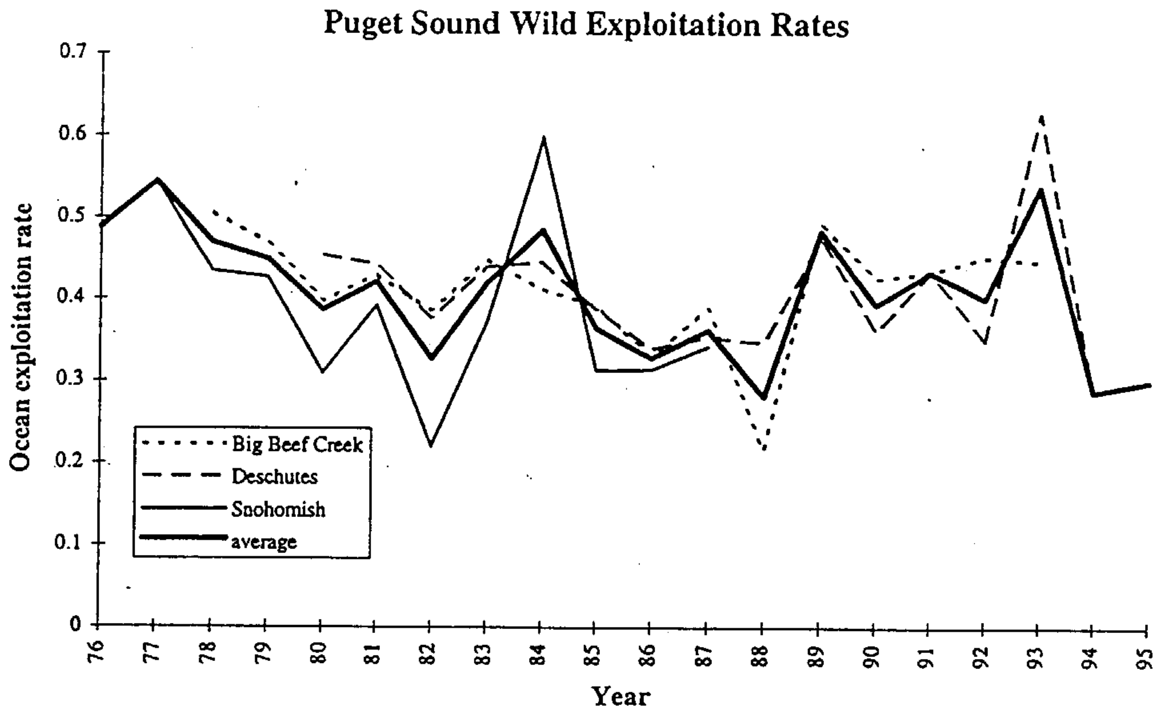


Figure 22. Estimated ocean exploitation rate indices for coho salmon from wild-fish tagging studies. Based on data from D. Seiler (WDFW, Pers. comm., 3 Nov. 1995).

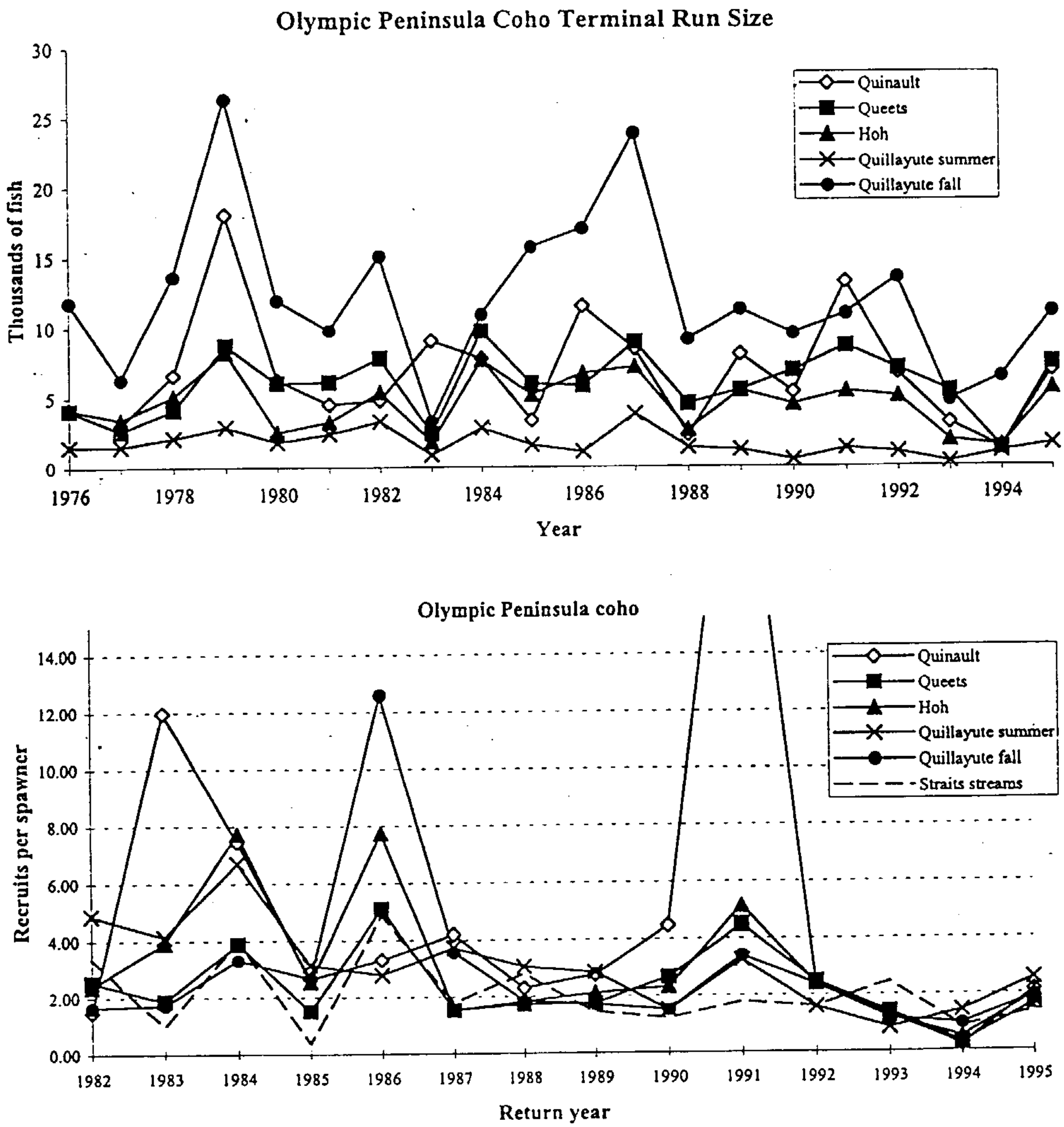


Figure 21. Estimated terminal run size (upper panel) and ocean recruits per spawner (lower panel) for Olympic Peninsula coho salmon stocks. Based on data from NWIFC (1996b, 1996c) and Quinault Indian Nation (unpubl. data).

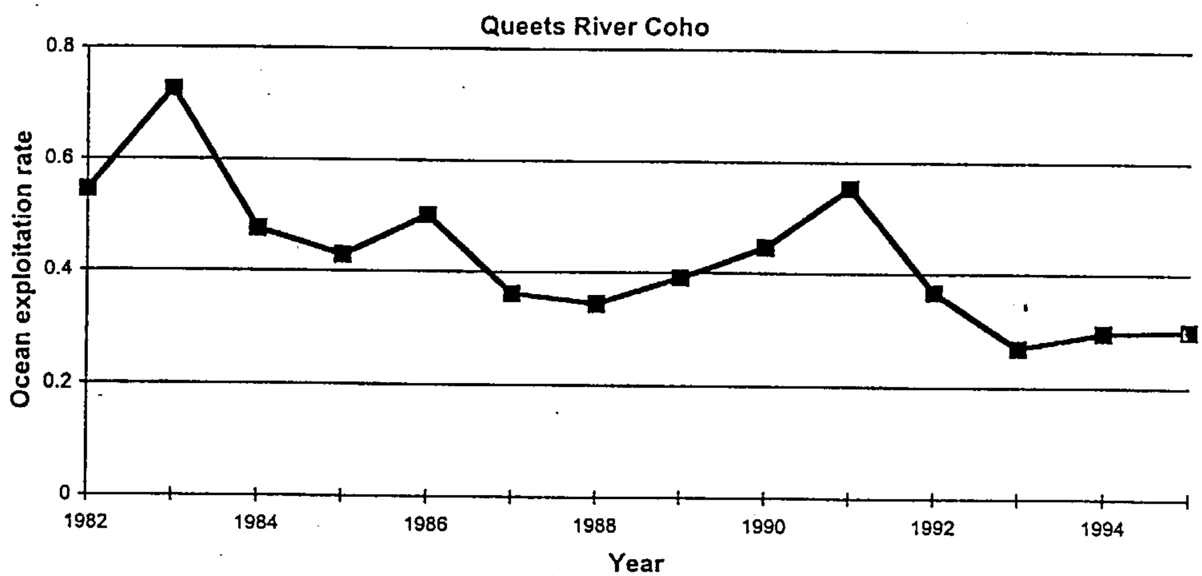


Figure 20. Coho salmon ocean exploitation rate index for Queets Hatchery stock, based on coded-wire tag data (Quinault Indian Nation, unpubl. data).

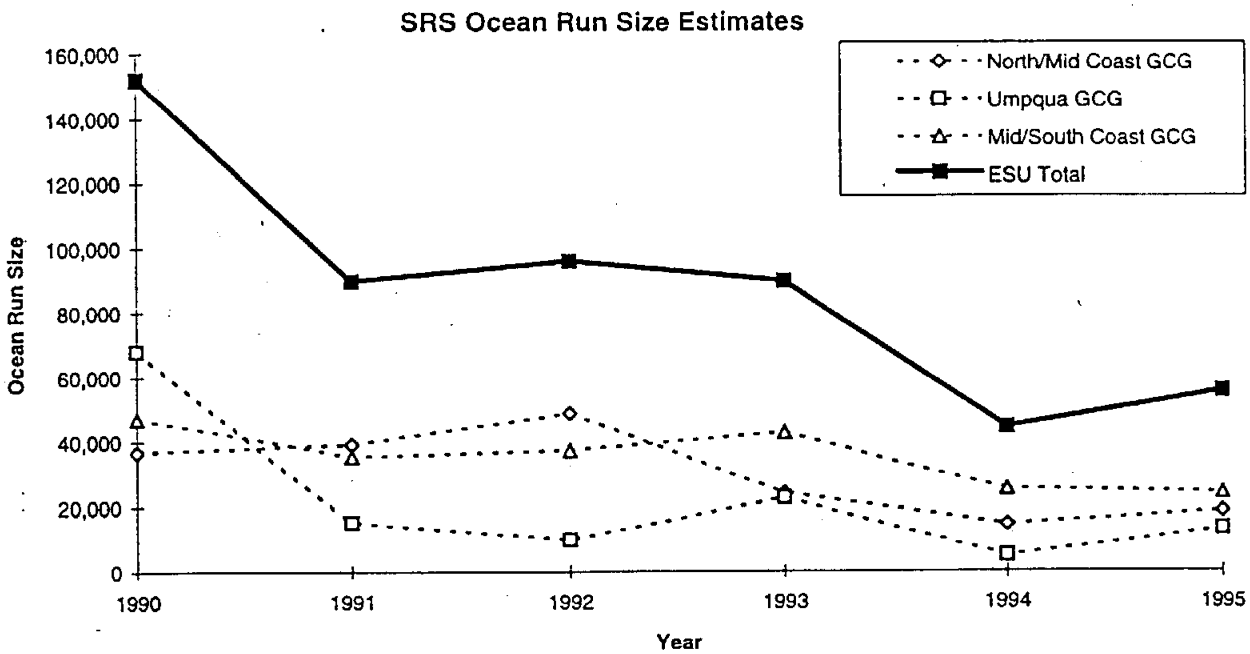


Figure 19. Estimated total ocean run size of coho salmon in the Oregon Coast ESU based on stratified random survey information (Nickelson 1996, S. Jacobs, ODFW, Pers. comm. 2 December 1996).

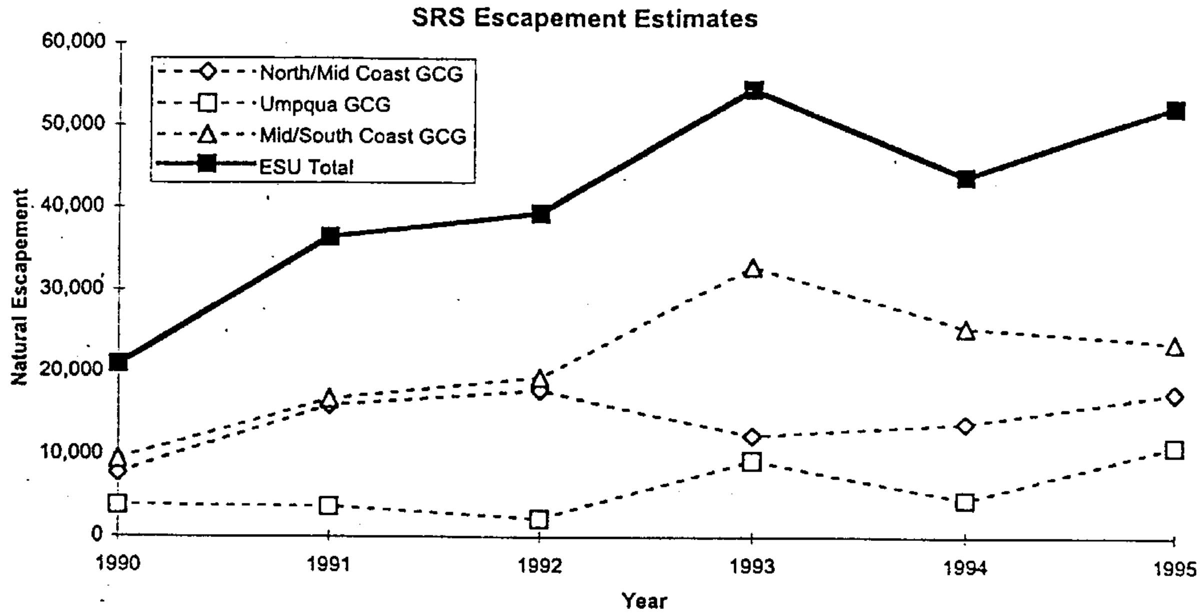


Figure 18. Estimated total adult escapement of coho salmon in the Oregon Coast ESU, based on stratified random survey information (Nickelson 1996, S. Jacobs, ODFW, Pers. comm. 2 December 1996)

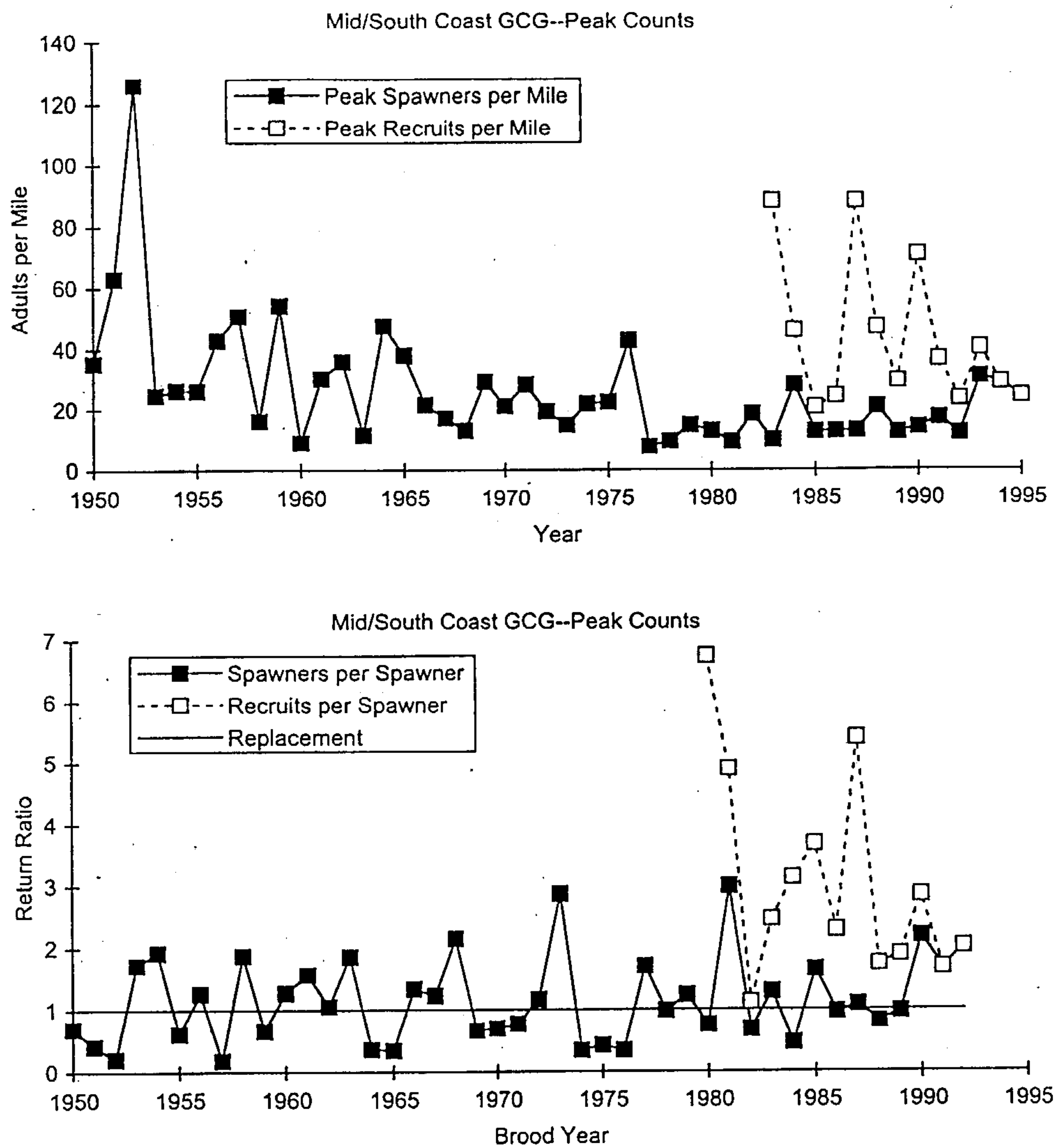


Figure 17. Estimated abundance (upper panel) and returns per spawner (lower panel) of coho salmon adult spawners and ocean recruits in the Mid/South Coast Gene Conservation Group. Estimates based on peak counts in standard survey segments (S. Jacobs, ODFW, Pers. comm. 8 May 1996).

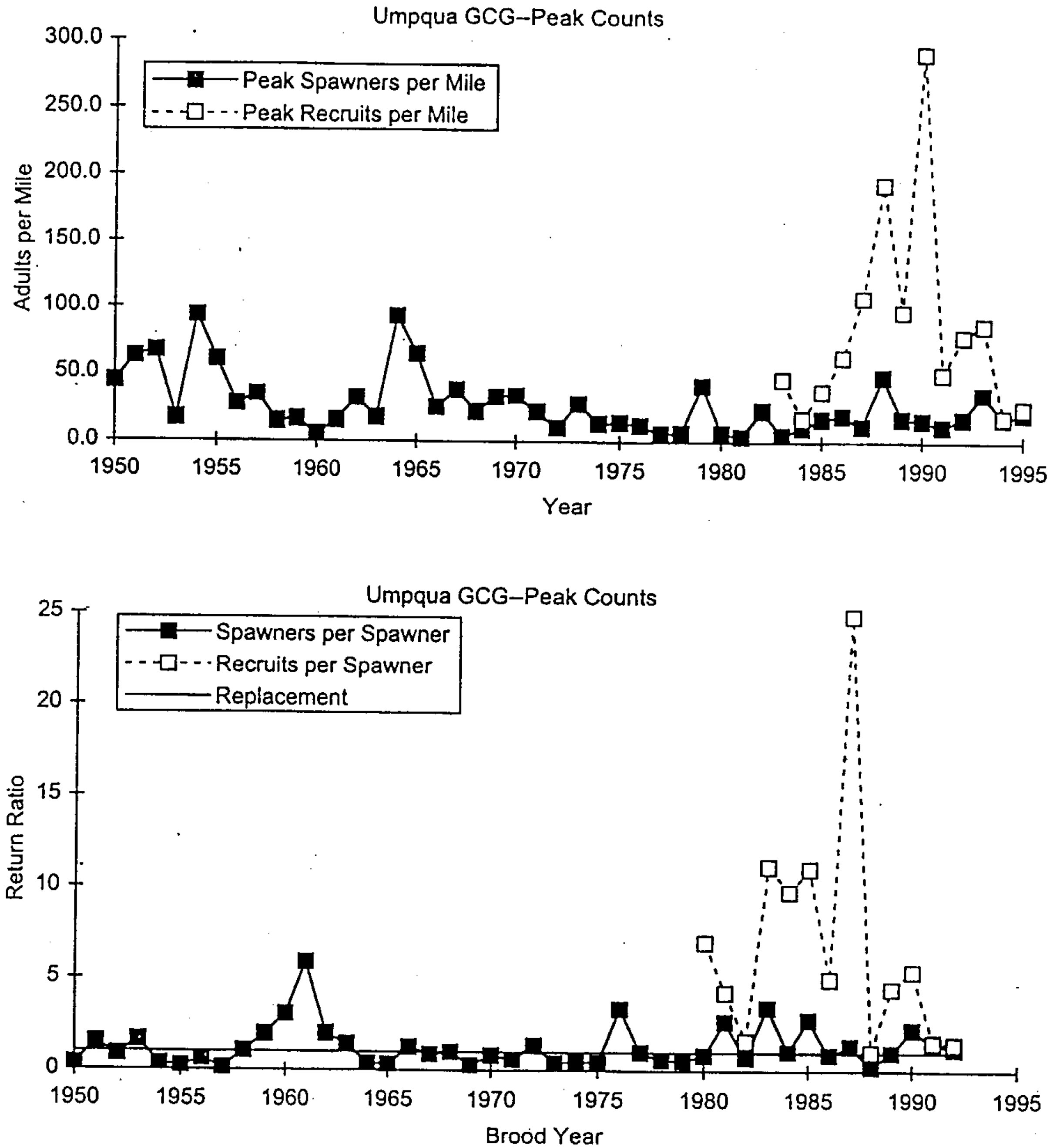
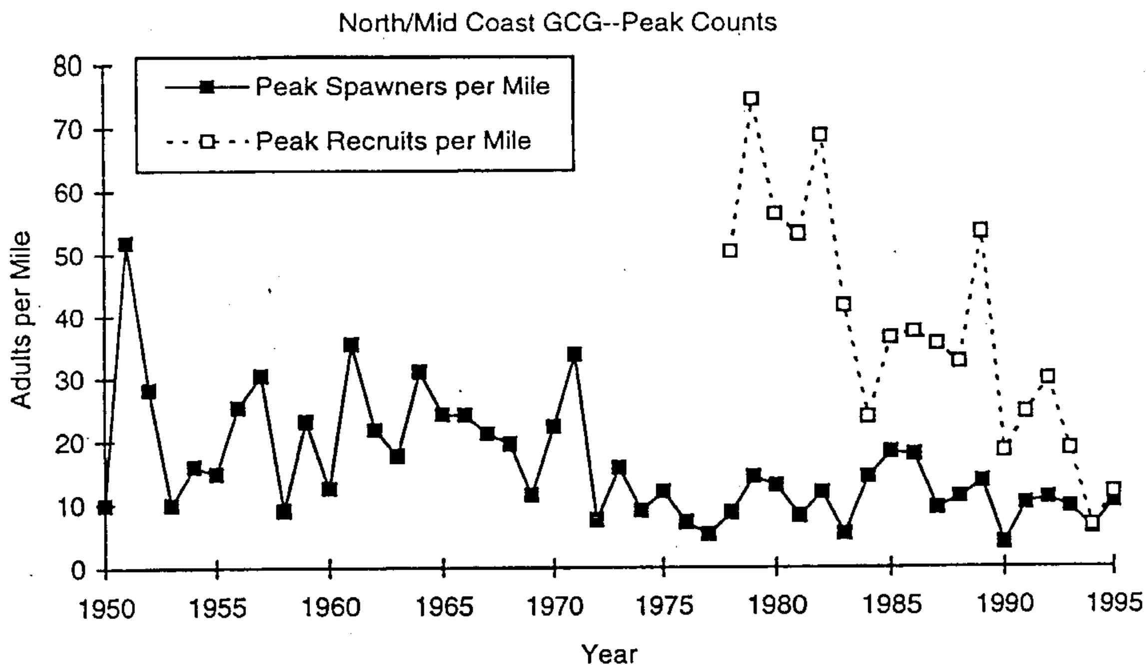


Figure 16. Estimated abundance (upper panel) and returns per spawner (lower panel) of coho salmon adult spawners and ocean recruits in the Umpqua Gene Conservation Group. Estimates based on peak counts in standard survey segments (S. Jacobs, ODFW, Pers. comm. 8 May 1996).



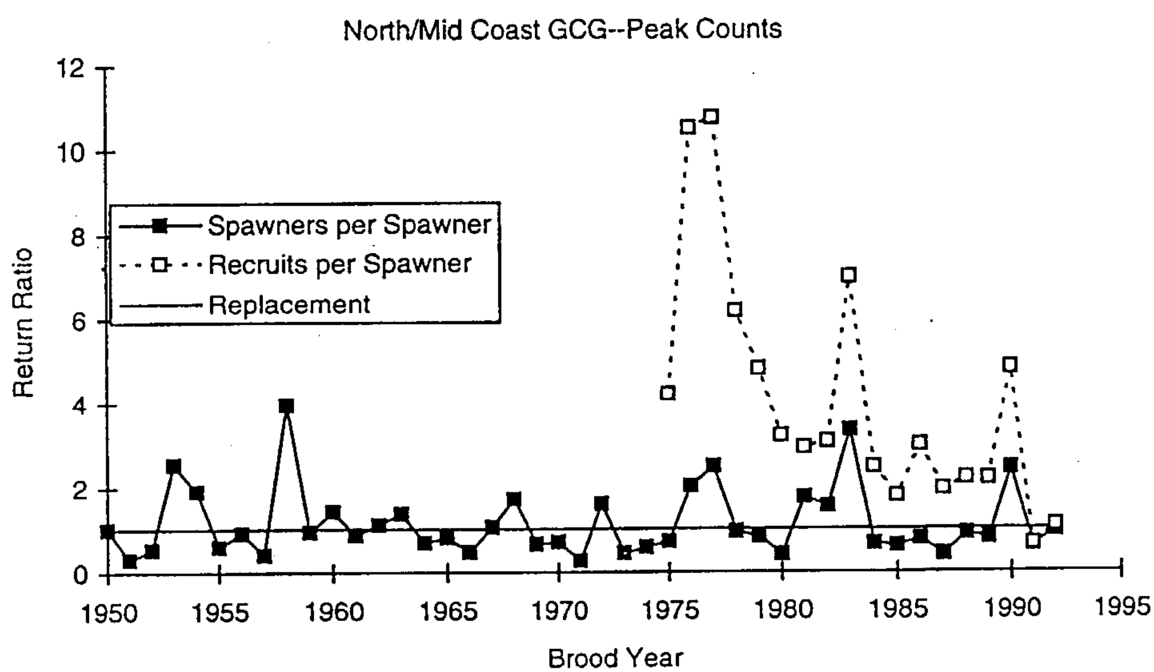


Figure 15. Estimated abundance (upper panel) and returns per spawner (lower panel) of coho salmon adult spawners and ocean recruits in the North/Mid Coast Gene Conservation Group. Estimates based on peak counts in standard survey segments (S. Jacobs, ODFW, Pers. comm. 8 May 1996).

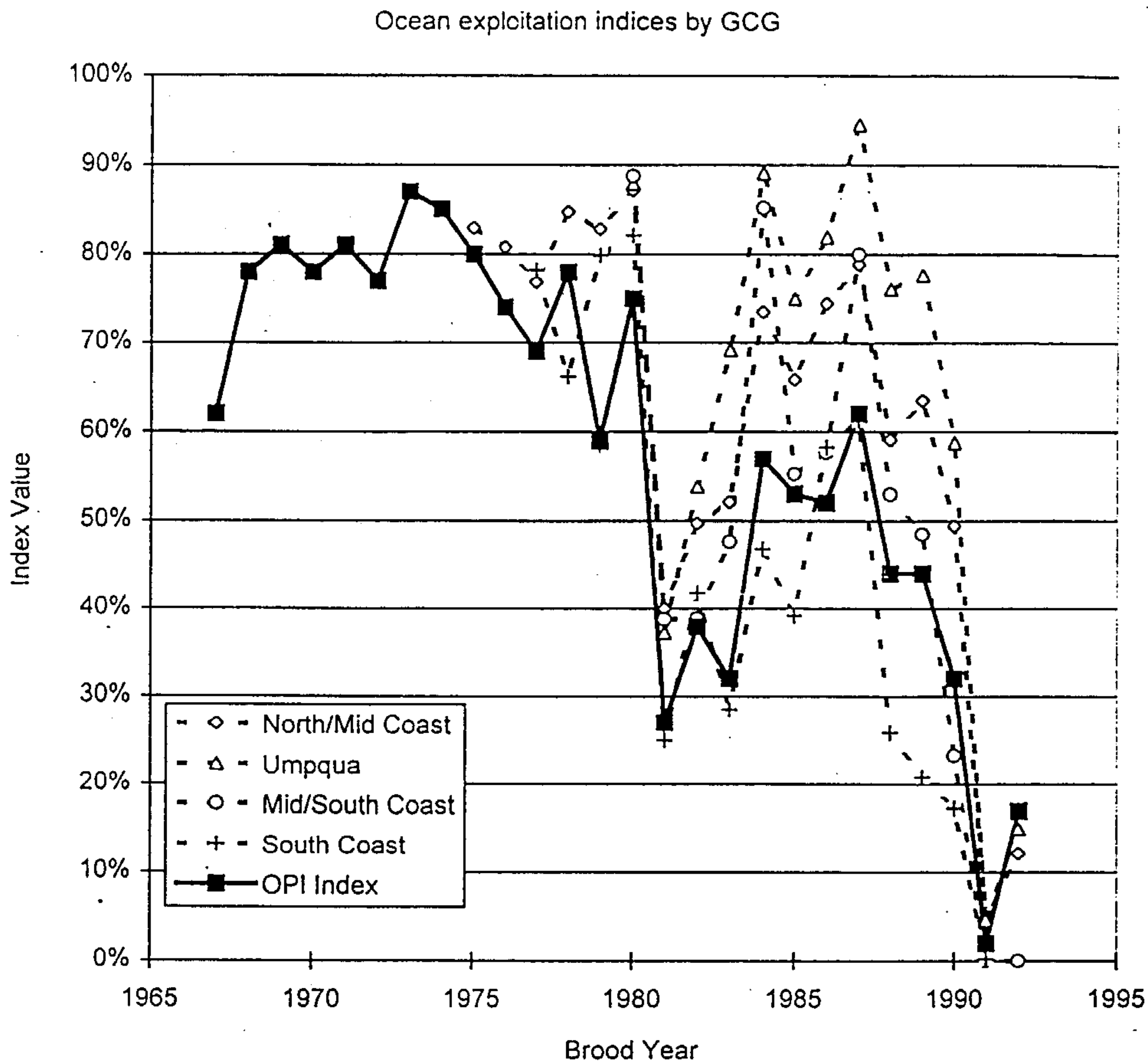
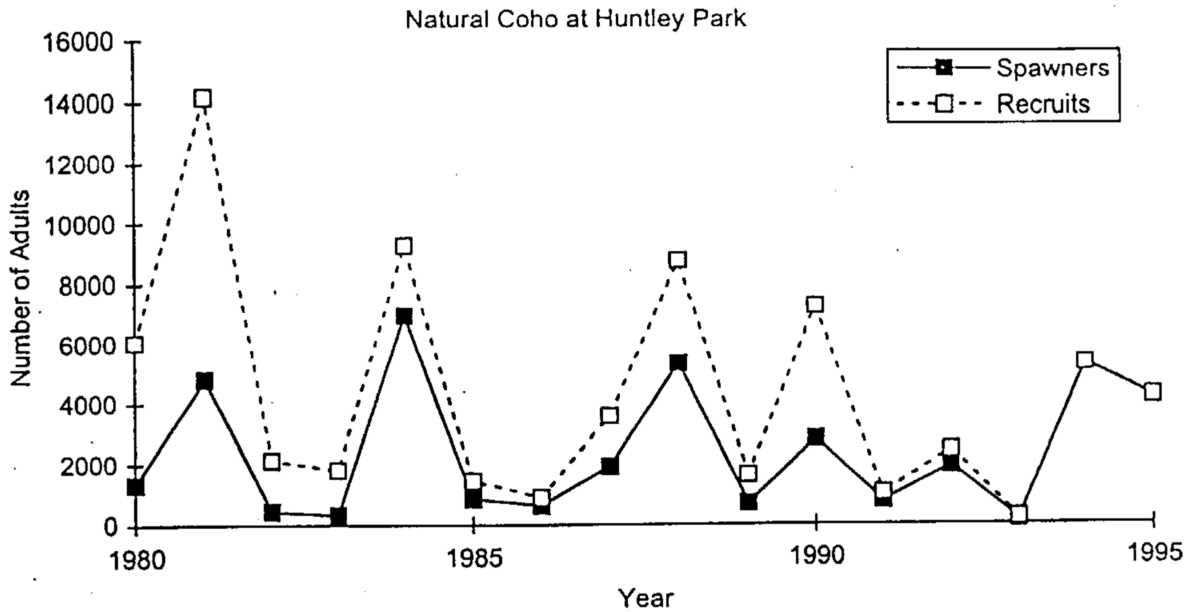


Figure 14. Ocean exploitation indices estimated for four Oregon coast gene conservation groups from coded-wire tag data for Oregon coast hatcheries (Lewis 1996), compared with the OPI index (PFMC 1996).



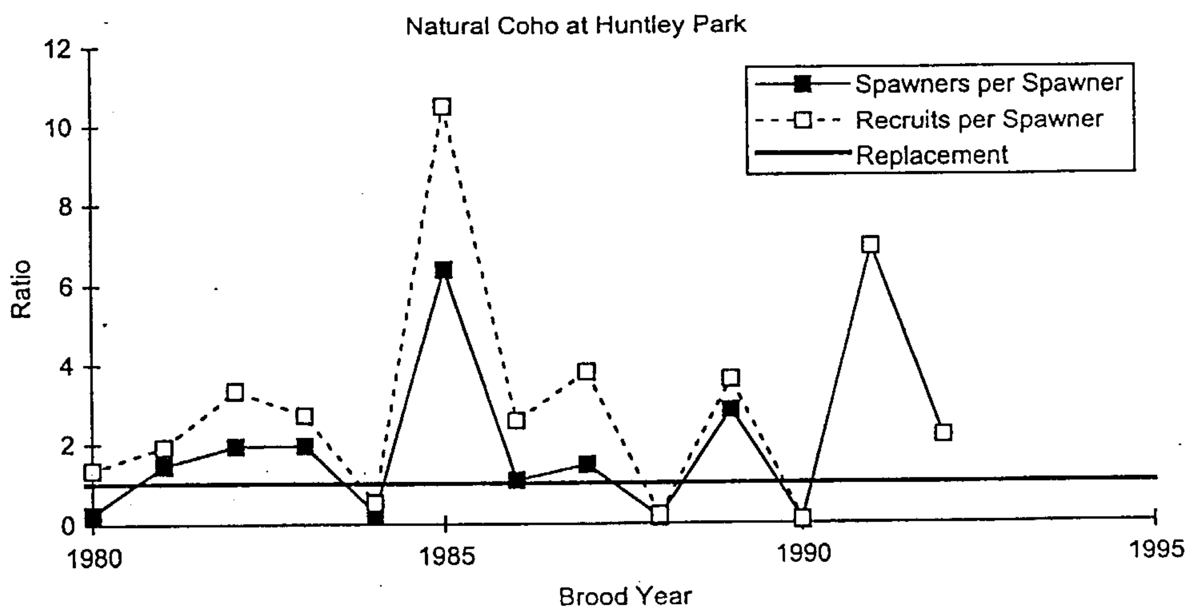


Figure 13. Estimated abundance (upper panel) and returns per spawner (lower panel) of naturally produced Rogue River coho salmon adult spawners and ocean recruits. Estimates based on expansion of seine-net samples at Huntley Park (T. Nickelson, ODFW, Pers. comm. 15 May 1996).

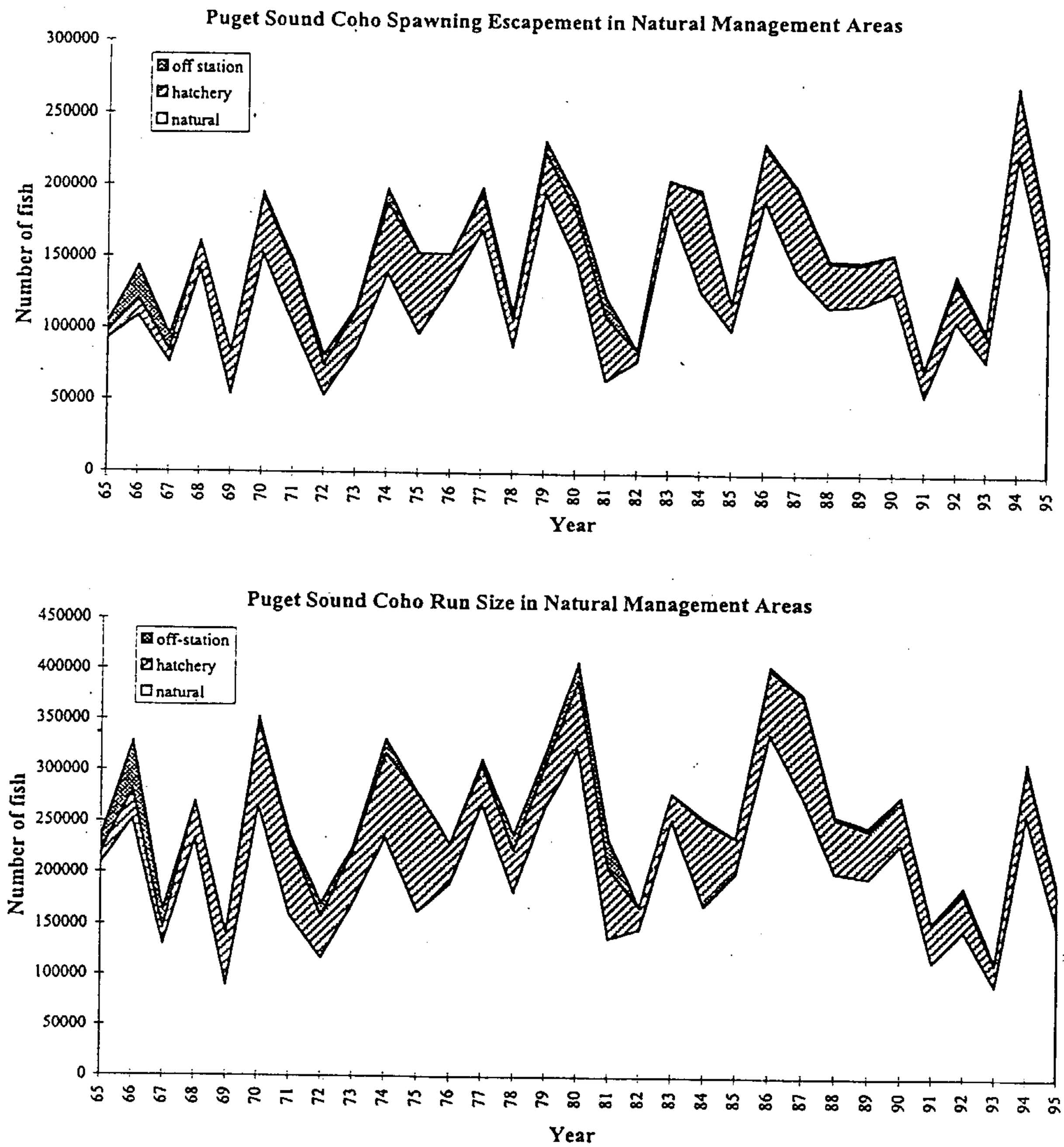
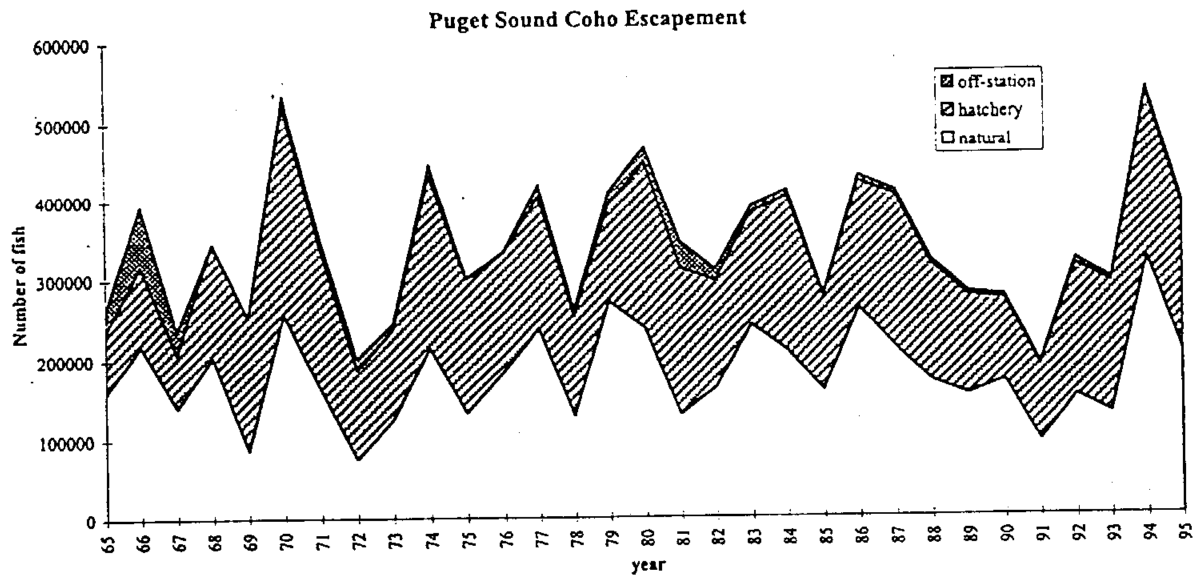


Figure 12. Estimated total coho salmon escapement (upper panel) and run size (lower panel) for natural management areas of Puget Sound. Based on data from NWIFC (1996a).



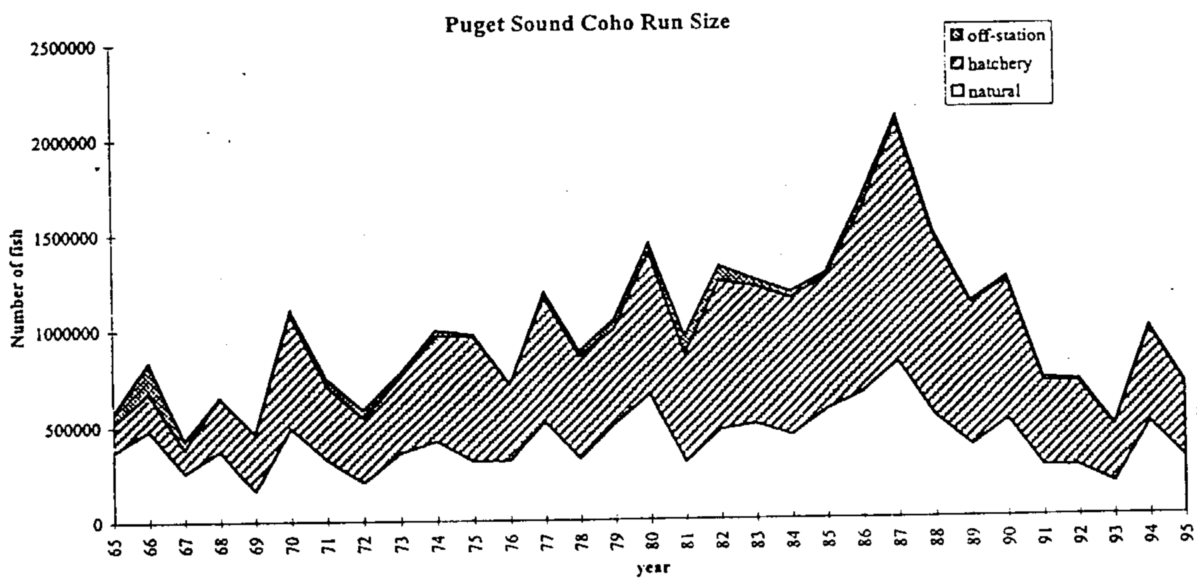


Figure 11. Estimated total Puget Sound coho salmon escapement (upper panel) and run size (lower panel). Based on data from NWIFC (1996a).

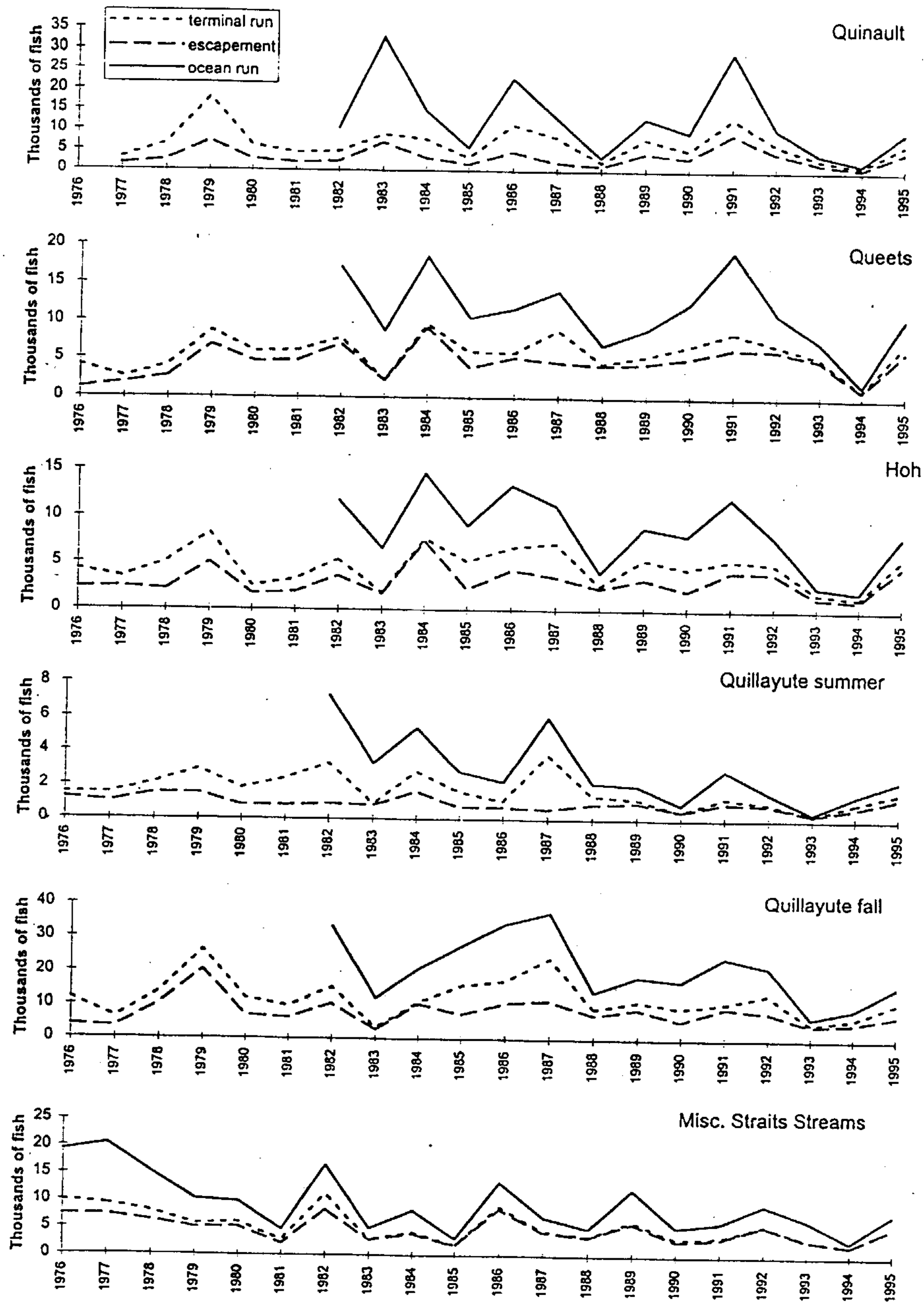


Figure 10. Estimated coho salmon spawning escapement, terminal run size, and ocean run size for Olympic Peninsula stocks (NWIFC 1996b, 1996c).